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## THE ANCIENT INDIAN POTTERY OF MARAJÓ, BRAZIL.

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Fig. 62 (Face).

Fig. 63 (Back of Head).

Head of Idol, Marajo.

THE existence of Indian burial places at various localities, in the Valley of the Amazonas, in which the dead were interred in earthen vases or pots, seems to have long been known. Von Martius* mentions the occurrence of these vases near Manáos, at Fonte Bôa and Serpa, on the Rio das Trombetas, and elsewhere. He besides incidentally refers† to the recent discovery of large collections of them at a place on the Island of Marajó, or Johannes,

* Zur Ethnographie Amerika's zumal Brazilien, p. 440.

† Op. cit., p. 178.

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called Os Camutins.* These last he supposed to be of Tupí origin. The same author says that the Tupís sometimes buried their dead in vases which were rude and unornamented. The Omaguas still use this mode of interment, but the vases are buried in the huts. I was informed at Rio das Contas, in the southern part of the Province of Bahia, that the Patachos bury their dead in earthen jars.

I do not know that any systematic examination has ever been made of any of the ancient Amazonian burial places. Last summer, while at Pará, Senhor Ferreira Penna, late Provincial Secretary, and the author of a very excellent little book† on the western part of the Province, called my attention to the fact of the existence of the Marajó pottery at Lake Arary. Being unable to visit the locality in person, I sent one of my assistants, Mr. W. S. Barnard, to examine it. Mr. Barnard reports that Indian burial stations are quite numerous in the centre of the island. The principal ones are, however, the Island of Camutí in the Rio Anajas, near the Fazenda de São Luiz, and probably the same called Os Camutins, by Von Martius; another near the Fazenda da Fortaleza, consisting of a mound from eight to twelve feet high, built up on the flat campos, forming an island during the annual overflow, and full of vases; another on the campo near Lake Guajará, which Mr. Barnard thought might contain four or five acres; but the most interesting appears to be the *Ilha das Pacovas*‡ in Lake Arary, which was visited by my assistant.

The Ilha das Pacovas lies close to the western side of the lake, opposite the beginning of the Rio Arary, which forms the outlet to the lagoa, and just to the south of the mouth of the Igarapé das Armas. It is oblong in shape, about ninety paces in length from north to south, and about forty paces in width. In the month of November, when the water was low, it was somewhat over ten feet in height above the level of the lake. It is for the most part covered with large forest trees. Situated at the northern end of the island, and separated from it by a narrow channel, is a little crescent-shaped islet apparently built on as an addition,

* *Camuti* is the Tupí word for *pot*. The Portuguese often write it *Camutim*. Treated as a Portuguese word, the plural would, in this case, be *Camutins*.

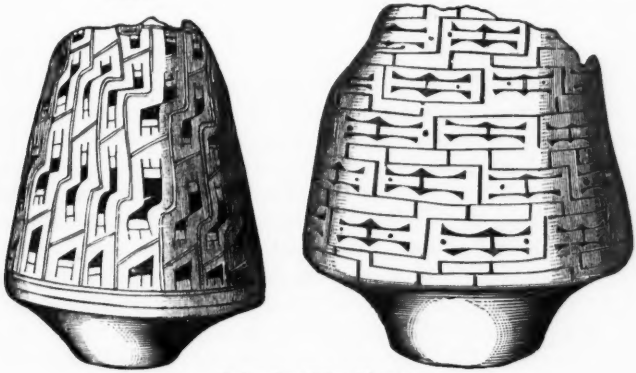
† Entitled, "A Região Occidental da Provincia do Pará," and published by the government.

‡ *Pacova*, Portuguese form for Tupí *pacúa*, a banana. The island takes its name from the banana trees growing upon it.

and not so high as the main island. Both were evidently raised artificially, and are full of burial vases and pottery of all kinds. The vases, which are about three feet in height, are, in some places, buried as many as three or four above one another, but they are more or less scattered. The waves have worn away the edges of the island making a sloping shore full of broken burial jars and thickly strewn over with fragments of pottery.

Mr. Barnard made no excavations. He, however, collected specimens, in a more or less broken state, of what was at hand. His collection consists entirely of pottery. Bones were very rare, and very much broken up. I regret exceedingly, that of these re-

Fig. 64. Fig. 65.



Indian Burial Jars, Marajo.

mains, none were brought home, but I may state here, that an expedition is on foot to thoroughly explore this, as well as some of the other localities.

Of jars or vases used for burial purposes (*ygaçaua*, * *ygaçauaocú*, *camuti*, Lingoa geral) there are two in the collection, large specimens which show quite well the form, together with a number of fragments. The two more perfect specimens (Figs. 64 and 65), are of the same general shape, but they differ in the style of ornamentation. Both consist substantially of two truncated cones united by their bases, the apicial angle of the lower cone being much more obtuse than that of the upper, so that the greatest

* Ygaçaua (*igaçaba* of Tupí dictionaries) properly means a large waterpot.

diameter of the vessel would be at about one-tenth its height, measuring from its base. The vase represented in fig. 64, judging from the curving outwards of the upper broken edge, as well as from the ornamentation, must have been little less than twenty inches in height. The diameter of the mouth I cannot give; the greatest diameter, measuring inside, is fourteen and three-fourths inches; that of the base is about five inches inside. The sides of the upper part of the jar slope regularly. Those of the lower part are slightly concave. Though skilfully made, it is nowhere exactly round, and bears no marks of having been shaped on a wheel. All the Marajó pottery was made by hand. The material is a rather fine clay with little or no sand. I have not observed, in the ancient Marajó pottery, any admixture of the ashes of the Caraipé tree (*Licanea utilis*), which are extensively used, at present, both by Indians and whites. The vase under discussion has broken with a very irregular fracture. The thickness at the base is about half an inch, at the top about a quarter. The outside of the vase appears to have been shaved down smooth, probably with a piece of wood, and washed with a fine whitish clay which has darkened in burning. The surface is very smooth, but quite irregular. The base and inside have not been polished. The ornamentation is unique and is well shown in the engraving. The lines are deeply engraved. The broad shaded portions of the chair-like figure have been roughly scraped, apparently by a stick with a broad flat end. These portions, as well as the lines of the figure, have received a wash of red clay laid on very daubily. The broad line, just above the base, is colored in the same way, but the double lines, separating the figures, are uncolored. As will be seen from the engraving, there is considerable variety in the rendering of the design.

The other vase (fig. 65) differs from that just described, in being a little larger, and in having the sides of the basal portion more concave. The material and the surface finish are the same, but the wash of cream-colored clay is of a somewhat lighter color, and the surface has a hard, glazed look. The pattern is quite as singular as that of the vase just described. The designs and all the double lines are washed with red clay daubed on as before. This vase is slighter than its companion.

Both of these vases were probably furnished with projecting knobs or ears (*nambi*) around the mouth. These are often in the

form of heads of animals and men. They are readily broken off, and large numbers of them were picked up on the shore amongst the broken pottery. In the collection is a fragment of another burial urn, whose greatest diameter must have been about two feet. It appears to have been made on the same pattern with fig. 64. The design was substantially the same, but the chair-shaped figure was more drawn out and disposed horizontally. The surface of the vase has the same creamy wash, and the engraved design is painted red. The bounding lines are treble or quádruple, and not colored.

Another fragment is of quite a small vase about eight or ten inches in diameter. The upper part, for apparently somewhat less than one-third the length, is swollen out, and ornamented with scroll-shaped bosses, curious knobs, and engraved figures. The part immediately below this raised portion is cylindrical, and ornamented with figures thrown into relief by deep, wide, engraved lines. The upper bulging portion received a wash of creamy white clay, and the lower part a similar coat of red clay. The whole surface was evenly smoothed, and the line-figures were cut in, or scraped out. One of the tools, used in cutting, had a narrow chisel-like edge, and was probably the tooth of some rodent. Where large surfaces have been cut down, the parallel marks of the tool are very distinct. The mouth of this vase was slightly funnel-shaped, and the lip probably bore ornaments.

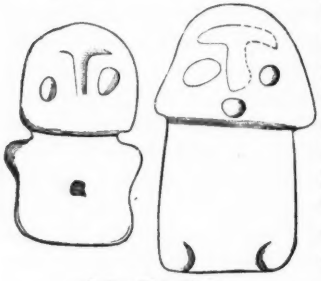
In addition to the above vases there are two other fragments of less interest. One indicates a vase, the body of which must have been about eight inches in diameter, and over a foot high. It is rudely smoothed inside, but the outside is rough and without ornament. The other was, in the body, at least, cylindrical, and about five inches in diameter. The outside was washed with red clay. A sort of geometrical pattern is cut through this into a lighter material below.

It is just possible that some of the smaller vases, above described, may not have been intended for burial purposes. The largest are too small to accommodate a skeleton, even if disarticulated. All the bones found in the urns were fragmentary. The probabilities are that the bodies were burned, and that only the ashes and charred bones were placed in the urns. An analysis of a small amount of black ash-like earth, found adhering to one of the jars, was made for me by one of my students, and found to contain a very large percentage of phosphate of lime.

There are two or three disk-shaped objects in the collection, which were probably used as covers to the jars. One of these has on one side curious engraved figures, which do not appear to be mere ornaments, but to be of a hieroglyphic character. This I am unable to figure here, but I shall describe it in another paper.

Of images or idols there are several in the collection, the most being in a more or less fragmentary condition. The largest of the specimens is represented in fig. 67. The body is nearly cylindrical, with two projecting knobs at the base for feet. A constriction represents the neck. The head was made quite round at first, but the after application of a high, wide, and angular ridge of clay, running completely over it from side to side, gives it a flat look. This ridge ends abruptly on each side at the neck and is there produced slightly outward. The brows and nose are represented by a T-shaped ridge of clay, applied in the same way as the crest; the eyes and mouth are simply round prominences. The brow and nose and the right eye have scaled off from this figure. The material is red clay with a wash of white. The surface is very rough, and the whole is very rudely made. The figure, from its weight, is evidently hollow, as were most of the others. The height is five and a half inches.

Fig. 66. Fig. 67.



Indian Idols, Marajo.

The figure represented in outline in fig. 66, is solid. It is exceedingly rudely made of coarse clay, full of sandgrains. The features are very indistinct. The brows and nose are represented by a T-shaped ridge. Slight projections from the shoulders hint at arms, and at the base are two irregular prominences as in fig. 67. The extreme flatness of the head is remarkable. In front is a hole, but whether accidental, or purposely made, I cannot determine. The height of the figure is about three and a half inches.

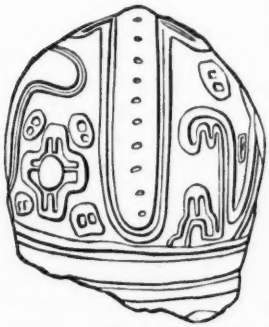
The same type of head and features recurs in the larger and more artistically finished head, of which fig. 68, is a representation. This last is also flattened, and shows the same transverse crest which, just opposite the eyes, is bent forward on each side. The united brows and nose form a wide, prominent, T-

shaped ridge as in the other figures, the alæ of the nose being, however, well formed, though unsymmetrical. The eyes are round and very prominent, the pupil being represented. The mouth is a low, rounded elevation. The face received a wash of white clay. Around the brows and nose runs a wide, shallow groove painted red; a similar groove surrounds the eyes. The broad bands on each side of the mouth are also painted red. The other lines represented in the cut are engraved with a sharp point. The pattern enclosed in the rude circles occurs on other pieces of pottery from the same locality, as we shall see farther on. The back of the head is smooth and unornamented. The figure was hollow, the body probably resembling that of fig. 67. It was built from the base upward, the top of the head being the last part formed. Layers of clay were laid on one above the other, overlapping inside, and then pressed into shape by the fingers, which were introduced through a hole in the top of the head. The imprints of the fingers preserve sharply the impressions of the striæ of the skin, showing the direction from which the fingers were applied. Finally, a cap of clay was applied above, closing the opening, and the figure was worked into shape from the outside. The height of the head is three inches; breadth, four inches. Another head, also separate from the body and represented in figs. 62, 63 and 69, is larger than the others and in some respects more elaborately executed. It resembles them, however, in its being flattened, in its being furnished with the transverse crest, which, in this case, is low and rounded, and in the T-shaped combined brows and nose. It, however, differs from the images just described in the grotesque ornamentation of the eyes, cheek

Fig. 68.

Head of Idol, Marajo.

Fig. 69.



Side view of the head of idol represented in Figs. 62 and 63.

and forehead, and in the figures on the back of the head. All these are so well shown in the engravings as to need no description. The form of the mouth is peculiar. This figure was made in the same way as the last described, being built up from below, the top of the head being the last part formed. Instead of heavy, irregular layers of clay seen in the inside of fig. 68, the inside of this head shows fashioning by the aid of a narrow, flat-pointed instrument of wood or bone, which was introduced from above and before the head was finished, and turned round and round leaving shallow, irregularly concentric furrows, which extend nearly to the top. The outside was moulded so as to give the transverse crest, the brows, nose, eyes and mouth prominence. The surface then received a red wash. After this the ornaments were left in relief by the cutting down of the surface. The principal tool used had a narrow, chisel-like edge, slightly hollowed, which left a little elevation running along the middle of the groove cut by it. This instrument, I believe to have been the tooth of some rodent. The marks it made are very distinct, but it has been difficult to represent them satisfactorily in the engravings. It is hardly necessary to add, that all the features and the ornaments in relief are red, while the background is the color of the light, unpainted clay. A fragment of the body below the neck is preserved, showing part of a red figure in relief, so that, without doubt, the whole idol was ornamented in the same general style as the head. The height of this specimen is four and a half, and the breadth four inches.

Fig. 70.

Head of Idol, Marajo. Front view.

The ornamentation of the head just described might be regarded as capricious, were it not for the occurrence in the collection of the head of another idol (Figs. 70 and 71), which resembles it very closely. This last has not only the same shape of head, but the same pattern of ornamentation, though the latter is expressed in a more simple manner. There are, besides the same

broad raised lines bordering the crest, brows and nose. The mouth is not represented. The ornament about the eye is substantially the same in both, but in the smaller head it has only two salient parts, or rays. It is interesting to observe, that the little eye-like figure of which in the larger head there are four about each eye is not wholly forgotten in the smaller head, but it makes its appearance in the lower outer corner of the right cheek, as an irregular hollow square. The central boss on the back of the smaller head (Fig. 71), and the W-shaped figure in which it stands, form manifestly the same design as that seen on the back of the larger head. The two upper eye-shaped ornaments on the back of the larger head appear on the smaller as hollow squares. The two lower in the smaller head correspond to ornaments, which, in the larger are attached to the border. More of the body of this second image is preserved than of the other. The specimen (Fig. 70) is about three inches in length. The ornamentation consists of raised lines forming hollow, angular figures unsymmetrically disposed both in front and behind. Part of the crest is broken away. The ornamentation was unskilfully executed with a very coarse tool. Since these two heads were found lying loose, and at a distance from one another, there is little probability of their having been made by the same hand. The points of resemblance between them indicate the existence of a recognized and common design, which cannot but have a significance. Which is the elder of the two, and which corresponds more nearly to the original pattern, it is impossible to say. These images appear to have been of a sacred character, but whether they were used as idols during the life time of the individual, and buried with his ashes, or were sacred figures used only in burial, is not clear. I am unable to describe the mode of association of these images with the burial urns, as the former were picked up loose.

Fig. 71.

Back view of Head represented in Fig. 70.

In connection with the vases and images, pottery of various kinds occurs. There are flask-like water-bottles, quite like those in use in Brazil to-day, cups, flat dishes and pots of various kinds, some very coarse, others highly ornamented with painted and en-

graved lines, and with ears representing animals' heads or human figures.

In Fig. 72, *n*, is represented a fragment of what may have been a ladle. The fragment is slightly concavo-convex and three and one-half inches long. Both sides were scraped down to a very smooth surface, which received a very thin coat of cream-colored clay, giving it a glazed look. The convex or outer side is traced with a rather elegant line-pattern in dark red, not engraved, which appears exceedingly well in contrast with the light background. Near the pointed extremity is a hole, showing wear, doubtless intended for a string. A shallow dish, of which I have a fragment, is painted inside very much in the same way as that just described, while another has a coarse figure drawn in dark umber on a light ground. I may remind the reader, that the variegated clays of the Amazonian deposits furnish very vivid tints, as reds, purples, browns, blues and yellows.* With these colors, the Indian women of Monte Alegre and elsewhere paint elegant designs on drinking cups of gourd (*cuias*), upon a background of *Cumatí* ("*Apocynea* vel *Asclepidea follicularis ?*" Mart.). I have observed no trace of the use of the resin of the *Yutahy-sica* (*Hymenæa* sp.) extensively used to-day on the Amazonas, for glazing vessels intended for use over the fire.

The Indians of the Amazonas use an earthen utensil for broiling or smoking various articles of food. It is like a large, deep, heavy basin somewhat wider at the mouth than at the base but with no bottom. This is inverted over a slow fire, the food to be cooked being laid on green stems of *taboca* (*Bambusa*), placed across the opening. This utensil the Brazilians call a *muqueador*.† A broken one ornamented with human features in high relief, was found at the *Ilha das Pacovas*.

There is a little cup in the collection about an inch and a half in height, ornamented with the design, *e*, fig. 72. In the engraving it is placed horizontally, but on the cup it is upright. The cup

* The yellow clay is called *Tauá*, the white, *tauá tinga* or white *tauá*. The Portuguese form is *Tabatinga*.

† The verb is *muquear*. This is one of the few Portuguese verbs derived from the Tupí. The same process is carried out by making a framework of green sticks supported on upright forked stakes. On this, fish, turtle's eggs, etc., are smoked and half cooked. The ancient Tupís cooked human flesh in this way. On the Amazonas the apparatus is called *muquem*. *Lery*, *Stade* and the old writers give the word *bucan*. Many words now pronounced with an initial *m* or *b* had originally an initial *mb*. Thus on the Amazonas one finds to-day *mboia*, *moia* and *boia* (*boa* constrictor).

is washed white, both inside and out, and the lines are engraved, together with the S-shaped design, which corresponds with the chair-shaped figure on the burial vase represented in fig. 65. This pattern, with its various modifications, resembles so closely the design occurring on the face of the image, fig. 68, and elsewhere, that all seem to be but different expressions of the same primary idea, which, in the beginning, at least, probably had some significance. The S-shaped design like that on the head, fig. 68, is sometimes formed by regular curves, but these are occasionally angular, in which case, the figure resembles the Greek fret. The opposing curves are always drawn with a double line, but the curves

Fig. 72.

*a*, *a*,' *a*," Ornaments on fragment of pottery; *b*, *b*', Fragment of a flat dish; *e*, Ornament on a little cup; *f* and *g*, Ornaments on fragments of pottery; *h*, Bead of pottery; *k*, engraved object; *m*, single design from vase, Fig. 65; *n*, Fragment of ladle.

are either not united at all in the middle of the figure, or if united, it is by a single line. In *a* and *a'*, fig. 72, from the same piece of pottery, and *f*, same figure, we have three modifications of the design, with curves united. In *b* and *b'*, fig. 72,* showing both sides of a fragment of a flat plate, they are not united. In some cases, as in *f*, *b*, and *b'*, fig. 72, the figure is ornamented by coarse shading between the double lines or by perpendicular loops or lines. On *b'* is a cross of the ordinary Christian type, but it is well known that this emblem is one of the simplest of ornaments in use, not only among pagan nations long before the Christian era, but to-day.

* The longest diameter of this specimen is four and a quarter inches.

If the maker of the pottery had attached the Christian significance to the figure he was drawing, he would not have represented it on the opposite side of the same vessel without the transverse bar, and if the Indians, who made the Marajó mounds had been christianized they would not have buried their dead in jars. It seems to me that the Indian artist, finding he had a large space to fill up on one side, drew a transverse line across the perpendicular one to make the figure larger. The cross also appears on *a'*, fig. 72.

The question of the primary significance of the S-shaped design I must leave to the student of the philosophy of art, together with the question of the independent origin of ornament, which also arises in the study of this pottery. The observant reader will detect the same pattern that I have just been describing, in use in carpets, ornamental borders and a hundred other places to-day.

Among other relics from the Arary mound is a large bead of clay roughly represented in fig. 72, *h*. It is very irregular in shape, rudely made, and the ornamentation is badly executed. It is much broken. Its length is two and a quarter inches.

Fig. 72, *k*, represents the end of an object cylindrical in the middle, and suddenly swelling out at both ends, one of which is broken. The design is deeply engraved, and the object was perhaps used as a stamp, but it is so irregular that it would have served very indifferently for that purpose. The width across the face is about an inch and three-quarters. A somewhat similar figure to that on the end is engraved on the side. The perforation extends nearly through from one end to the other. It might be taken for an unfinished bead were it not that two other partially perforated objects of a somewhat similar character are found in the collection. One of these is a lens-shaped piece of pottery, an inch and three-quarters across the flat face, which appears to have been ground into its present form. A hole is bored through it in a direction perpendicular to the centre of the flat face. The other is a pear-shaped object, about the size of a large marble, perforated in like manner from the smaller end. Its use I cannot divine.

We have no historical record of the tribe that built the Marajó mounds. Senhor Penna has had the kindness to examine carefully into the subject for me, and it would appear that the mounds antedate the discovery of America. We have no record of the existence of any tribe in the lower Amazonas within historic times, that buried its dead in jars. I do not feel like coin-

ciding with Von Martius in the supposition that the Marajó mounds were made by Indians of Tupí descent. There are many resemblances between the pottery of Marajó and that of Peru and North America that will be worth study. I hope that future explorations will enable me to clear up some of the doubts expressed in this paper, and cast much needed light on the ancient races of the Amazonian valley.

## APPLICATION OF THE DARWINIAN THEORY TO FLOWERS AND THE INSECTS WHICH VISIT THEM.*

THE first impression which flowers make upon us with the beauty of their radiate and symmetrical forms, their luxuriant display of colors and the variety and sweetness of their odors, easily begets in us the idea that they were created for delighting and gratifying our senses.

This, however, is a pleasing fancy which the Darwinian doctrine speedily annihilates. This doctrine teaches us that all the species of animals and plants now in existence are only the result of the same laws which, starting from the beginning of organic life on the earth and coming down to our day, have governed and continue to govern all animated things; and these are the laws of hereditary transmission and variation, of the struggle for existence and the consequent necessity that only those forms survive which best respond to external circumstances.

According to the Darwinian doctrine all the characteristics and properties of animals and plants appeared at first only as simple, *individual variations*, which were a necessary consequence of determinate physical and chemical actions,† and which, if they have

*Discourse delivered by Dr. ERM. MULLER of Lippstadt at the 26th General Assembly of the Naturhistorischen Verein für Rheinland und Westphalen, 1869. Translated into Italian from the German with Annotations by Prof. FREDERIC DELPINO. Translated for the NATURALIST from the Italian by R. L. PACKARD.

†The lively sense of fraternal friendship which unites me with the able author of this discourse cannot dissuade me from expressing my own views whenever they differ from his. I also am profoundly convinced that all variations were at first merely phenomena of individual variations subsequently fixed by the laws of hereditary descent.

been perpetuated, owe it to the circumstance that, in the struggle for existence, they were advantageous to those individuals in which they appeared. From the Darwinian doctrine, then, there springs the following thesis, which is of general application; that *in all animals and in all plants there is not a single characteristic, a single property, which is not either useful to its possessor, or at least is not inherited from ancestors more or less remote, for whom, at some time, it procured a decided advantage in the battle of life.*

Therefore, if we wish to apply the Darwinian doctrine to the rich and varied kingdom of Flora, we should, in the first place, answer this question: in what manner and by what means have the brilliant colors, the diverse odors, and the variegated structure of their flowers been of use to plants? The solution of this question cannot be obtained from a consideration of the flowers alone, for their properties are not *immediately* useful, but only *mediately;* and the mediation is accomplished by insects.

That flowers are visited by insects in various ways, and that many of them — bees, for example — are constrained to visit them for food, is well known; but this fact does not suffice to explain how these visits can be advantageous to the plants. Colors, odors, pollen, and honey seem at first sight to be of utility only to insects. If, as did C. C. Sprengel towards the close of the last century, we should propose to consider how insects act upon plants, and the wonderful conformity of floral structure which certain plants have with certain insects, we, like Sprengel, would easily fall into the belief that such harmonies are the cause of the insects effecting, without either knowing or willing it, the transfer of pollen from the anthers to the stigmas, while seeking their food in the flowers. But why should nature have entrusted to insects the

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but can in no way admit that the causes of these variations were *only determinate chemico-physical actions*. For who has ever been able to determine them, and who will ever be able? I should rather say that the causal principle of these variations is an intrinsic and not external one; an intrinsic principle reacting during the whole of life against extrinsic influences, or chemical and physical agents. I am far from wishing to deny the action or influence of external circumstances; but I think that these, as long as life lasts, and within certain limits, are ruled over by that internal principle, intelligent and free, which I suppose incarnate in all living things. I candidly confess that my mode of thinking is purely and simply theoretical; but the contrary thesis maintained by Müller and all the naturalists of our age, is also purely and simply theoretical, and always will be! and theory for theory, I prefer my own.

As to which of the two theories, the dualistic or the monistic, will ultimately gain the victory, I think I do not err in saying that the question is and always has been insoluble.

accomplishment of this transfer, when it would have been much more simple to dispose the organs in such a way that the anthers might cast the pollen immediately upon the stigmas? The reason of this Sprengel failed to comprehend, nor should we be more successful without recognizing an important natural law recently detected by the author of the doctrine of natural selection.*

Charles Darwin saw, what Sprengel failed to see, that the principal effect of the action of insects upon plants is the transfer of the pollen of one individual to the stigma of another. To this conclusion he was led by his beautiful researches on the floral structure and the fecundation of Orchids. And from these he subsequently inferred that it is advantageous to every vegetable to have its pistils fecundated by the pollen of other individuals of the same species, rather than by its own. As soon as observation had made Darwin master of this great truth, he resorted to the control of experiment. The experiments made by him with unwearied diligence through a long series of years — scattering upon the stigmas of plants of the same species, sometimes their own pollen, sometimes that of others — placed it out of doubt that *the impollination of the stigmas with the pollen of other individuals, or the intercourse between distinct individuals, produces an offspring more numerous, more robust, and capable of greater development than if fecundation had been produced by its own pollen;* a thesis which subsequently became amply confirmed by the numerous experiments of Hildebrand, my brother Fritz, and others. The enigma of floral structure is then solved, and we will now pass to the

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*The author attributes to Charles Darwin the merit of having first formulated the law of the necessity of cross-fertilization even for hermaphrodites; but this law, already partially seen by Kœlreuter, was comprehended in nearly all its vigor by C. C. Sprengel.

Kœlreuter having in 1761 made the discovery that in the Malvaceæ, Epilobia and Polemonia, the stigmas are developed long after the anthers, and therefore have to be fecundated with pollen from other flowers, makes the following shrewd remark. "An id aliquid in recessu habeat, quod hujuscemodi flores nunquam proprio suo pulvere sed semper eo aliorum suæ speciei impregnentur, merito quæritur. Certe natura nil facit frustra."

C. C. Sprengel went further, and on p. 43 of his work, "Das entdeckte Geheimniss der Natur in Bau, und in der Befruchtung der Blumen" (1793) uses these memorable words: "Since there are so many unisexual flowers, and since among hermaphrodite flowers there are so many that do not mature the male and female organs at the same time, it *appears that nature does not wish that each flower should fecundate itself with its own pollen.*" And he cites as a support an experiment made by him upon the flowers of *Hemerocallis fulva* which, after being fecundated artificially with their own pollen never perfected the seeds.

principal applications of the foregoing thesis in the explanation of the forms and properties of flowers.

If it is true that intercourse between distinct individuals produces a more vigorous and numerous offspring, it is equally true that every variation in the flowers which favors the transfer of pollen from one individual to another secures a notable advantage to the individual in which it takes place, and therefore cannot fail to be fixed and perpetuated by means of natural selection.

Now, as far as we know, there are only two external agents which can effect this transfer, namely, the wind and insects;—naturally with the contingence of very different floral structure.*

The different species of plants, as concerns the variations which first appeared in them, would, by natural selection, accommodate themselves to the wind or the visits of insects, by suitably modelling their flowers either upon an anemophilous or an entomophilous type.† The action of the wind is simple and uniform, while that of insects is extremely varied: therefore their self-adaptation to the action of the wind presupposes a variation in a single and definite direction; whereas that to the visit of insects takes place in as many different ways as there are differences between individual insects; that is to say, differences in size, form, structure, habits, modes of life, sympathies, antipathies, seasons, etc. Therefore, from the Darwinian point of view, we should expect to find: first, that the variations of plants arising from adapting themselves to the multiform actions of insects should have taken place far more frequently than those due to their adapting themselves to the uniform action of the wind; second, that plants modified to receive

* The numerous observations made by me in this field of biological study put me in a condition to enlarge a little upon what the author says here. The fecundating agents of plants besides insects and the wind I think are the following natural agents:—

The humming birds (Trochilus, Ornismya, Nectarinia, etc.) for a great variety of tropical plants; snails for *Rhodea Japonica* and some Aroideæ; water for *Vallisneria spiralis*, probably for all the Zosteraceæ and all the Florideæ (according to the recent and beautiful observations of Thuret and Bornet).

As to humming birds, never having been able to visit tropical countries I was obliged to limit myself to conjectures, which have subsequently been partly confirmed by letters from Charles Darwin as regards the fecundation of the genus Strelitzia, and from Fritz Müller as regards that of certain Passifloræ, Salviæ and other Brazilian plants.

† The terms anemophilous for plants fecundated by the wind, and entomophilous for those fecundated by insects were proposed on p. 34-35 of a work of mine upon the *arrangements for fecundation in anthocarpous plants* (Florence, 1867), and have been adopted by Severino Axell in his fine work *Om anordningarna för de fanerogama växternas befrutkning* (Stockholm, 1869) and by some others. That is why I permit myself to translate with such words the compound nouns *Wind-blüthen* and *Insect-blüthen*, used by the author, which cannot be literally translated.

the visits of insects should offer a much greater variety of floral forms than plants adapted to the wind.

These two propositions which are necessary consequences of the Darwinian doctrine are effectually confirmed by observation, for anemophilous flowers are not only less numerous than entomophilous,* but are also much less varied in their conformation.

The transfer of pollen by means of the wind demands that the anthers and stigmas be well exposed to the air, and it is also necessary for the pollen to be subtile and very light and dry, so as to be more easily carried by the air, and to be produced in enormous quantities so as to insure fixing upon the stigmas some one of its grains. Remarkable examples of such a disposition are afforded by the Cupuliferæ, Coniferæ, Graminaceæ, Juncaceæ and Plantaginaceæ.† If, for example, a bush of hazel in flower is shaken, or if

* If we think of the immense number of individuals belonging to the essentially anemophilous families of the Coniferæ, Amentaceæ, Graminaceæ, Cyperaceæ and Juncaceæ, and of the great number of flowers which every individual of them usually bears, the statement that anemophilous flowers are less numerous than entomophilous is subject to dispute.

At bottom, however, the principle maintained by Müller is most just; and the only change which occurs to me is to substantiate for his proposition this other; *anemophilous species are not only much less numerous, but also much less varied in the structure of their flowers than entomophilous species;* a most true and splendid generalization, which explains why in cold countries where the generation of insects is opposed by the climate, the whole of the vegetation is composed of anemophilous and gregarious plants (firs, birches, Graminaceæ and Cyperaceæ), and therefore desolately monotonous and poor in form; while in warm countries where myriads of insects abound, vegetation is most rich in diversity of forms and therefore composed of species not gregarious but entomophilous or ornithophilous.

† The genus Plantajo furnished me a most interesting subject of study, since by examining some of its species I saw how by gradual transitions an anemophilous species can change to an entomophilous.

*Plantago lanceolata*, as far as I could observe, develops in three forms. One of these has a stout and very high scape with whitish anthers which are quite broad and tremble in the wind, inhabits meadows and is exclusively anemophilous, as I have never seen it visited by insects. Another form is found upon hills, the stalk is not so high as in the first, and like it is essentially anemophilous. I saw, however, occasionally a species of Halictus light upon its spikes and try to gather the pollen; but the structure of the flower is so ill-adapted to such a purpose that the greater part of the pollen fell to the earth without being of use either to the insect or the plant. The third form is of small size, inhabits mountains, the spikes are very short, and the filaments shorter than in the others. In the pastures upon the Apennines of Chiavari I saw a great number of bees flying diligently from one spike to another, collecting pollen with perfect success and providing equally well for a promiscuous intercourse between the plants. There is, therefore, a form of *Plantago* perfectly intermediate between the anemophilous and entomophilous forms, and equally capable of being fecundated by the wind or bees.

Now if we suppose the filaments of this form to become rigid and colored, the pollen unctuous and sticky, and the anthers to lose their special tremulousness, we should reach the gradual metamorphosis of anemophilous into entomophilous characters, and witness the formation of an entomophilous from an anemophilous species. Exactly

we blow upon one of its mature catkins, we see at once small clouds of pollen emitted and carried away, and if immediately after we examine the surrounding stigmas we find very few which have not some granules of pollen attached to them. In this example, as a condition of the easy dispersion of the pollen by means of the wind, we have the excellent form of inflorescence of the male flowers arranged in catkins freely suspended in the air, and, as a condition of an inevitable intercourse between individuals, we find a separation of the sexes, which is a quite general phenomenon in anemophilous flowers. In other cases, for example in the Plantaginaceæ, the parts shaken by the wind are the anthers which hang suspended from long and very weak filaments, and the intercourse between individuals is obtained not by a separation of the sexes, but by a difference of time in the development of the sexual organs. In these plants, while the anthers are yet immature and enclosed within the floral envelope, the stigmas, perfectly mature, have already appeared in the form of long, plumose stalks; and only when the stigmas have passed maturity do the anthers appear. Such are the principal characteristic differences of anemophilous flowers.

The flowers fecundated by the intervention of insects are far more highly differentiated in the disposition of their parts. Yet here, too, some general conditions necessary to secure the visits of insects, and the transfer of pollen by their means can easily be determined. And in the first place, it is necessary that the insects should be able to distinguish such flowers at a distance. Now this can only obtain in three ways, either by means of the colors, or the odors, or both colors and odors at the same time. And this *a priori* deduction from the Darwinian doctrine is in harmony with the facts; for entomophilous flowers are either colored, or odorous, or colored and odorous at the same time. In like manner, odors and colors are *a priori* perfectly useless to anemophilous flowers, or those fecundated by the wind, and are not, therefore, properties which can be fixed by natural selection. With this, too, the reality corresponds perfectly, for anemophilous flowers have neither colors nor odors.

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what we here merely suppose, takes place in reality. The *Plantago media* is a Plantago which has become entomophilous; its stamens are of a beautiful rose color; the tremulousness of the anthers is lessened, the pollen has lost its volatility, and the plant is normally visited by *Bombus terrestris*, as I ascertained in the mountains above mentioned.

A second condition which is absolutely necessary to obtain a regular and indefectible visit of insects is, that the flowers furnish them some substance which is agreeable and of use to them. In the more simple cases, for example in Anemone and Clematis,* such a substance is the pollen which the insects feed upon, or gather as food for their larvæ. In other cases it is not only the pollen which is presented to them, but also honey, as in the Ranunculi, the Rosaceæ and many other plants. In still other cases the stamens withdraw themselves more or less from the depredatorial action of insects which then take from the flowers only honey. This takes place in the genera Salvia, Pedicularis, and Iris.†

*Not all the Anemoneæ nor all the Clematideæ are without honey. *A. coronaria, hortensis, pavonina, nemorosa,* and *Hepatica* are without nectaries, or seemed to me to be so, but in *A. pratensis* and probably in all the forms of the subgenus Pulsatilla, the outer row of stamens show different stages of atrophy, and have anthers more or less abortive and changed into nectaries. As to Clematis, it is true that some of the species are without honey, at least none has yet been found in them; but in *C. Balearica* and some others, the more external filaments are dilated and transmuted into real introrse honey-bearing receptacles, which Bombi and Xylocopæ visit. Finally in *C. integrifolia*, although the outer stamens, which are hairy and diluted, have no nectar, the much narrower and glabrous inner ones have nectarifluous filaments.

It is very difficult to determine whether a flower has or has not honey. It is frequently found where least expected and secreted by entirely different organs. I have been frequently mistaken in the search. For instance, although I have had occasion for three or four years to study the flower of *Caltha palustris*, it is only a short time since I discovered that from each one of its carpels honey transudes through two small rhomboidal spaces in its external surface. The discovery was made while observing the deportment of a Halictus in one of the flowers. I noticed that it not only gathered the pollen, but sought something else, turning its proboscis towards the centre of the flower. Then, instructed by the insect, I examined the flower more closely and found that its nectaries secreted a very dense and white honey. It is an incontestable fact that, in this kind of search honey-bees show greater sagacity than we ourselves. The same, however, cannot be said of Diptera, which are in general of obtuse intelligence. And, in fact, all the flowers which are destined to be preferably visited and impollinated by Diptera (flesh-flies, Eristalidæ, Syrphidæ, etc.), secrete honey in broad and open nectaries, easily discovered.

It is singular how honey is secreted by the most different organs. Thus, in the single family of the Ranunculaceæ the honey is secreted, 1, by the reddish margins of the sepals in certain of the *Pæoniæ;* 2, by the petals in Ranunculus, Myosurus, Trollius, Isopyrum, Helleborum, Nigella, Delphinium, Aconitum, Coptis; 3, by the abortive anthers in *Anemone pratensis;* 4, by the filaments in some Clematideæ; 5, by the carpels in the genus Caltha. So that in the Ranunculaceæ we have the singular example of all the floral organs, petals, sepals, stamens, and carpels, assuming and abandoning alternately the function of secreting honey for the advantage of insects.

†This does not accord with my observations. Our species of Salvia are visited almost exclusively by bees. When they thrust their heads into the fauces of the flower to suck the honey, the anthers, by means of a curious hinge movement, scatter the pollen upon their backs. Now the honey bees and Bombi collect this pollen carefully, brushing their backs with their legs from time to time. The same is true of Iris. I have frequently surprised a Bombus (I am uncertain whether a *B. hortorum* or *terrestris*) and *Xylocopa violacea* entering one of the three mouths of the flowers of this plant, and covering its back with pollen; after visiting two or three flowers it would

In much rarer instances, insects seek in the flowers neither pollen nor honey, but a different substance. Some Coleoptera which are of comparatively little importance in the fecundation of flowers, suck the tissues of the floral organs. In the case of a small orchid from Brazil, according to my brother Fritz, the lip becomes filled with a kind of flour. In other Brazilian flowers there are fleshy excrescences which the insects visiting those flowers gnaw.* A

rest a short time in order to brush itself with its legs and collect the pollen there accumulated. I have elsewhere described the admirable mechanism of the flowers of Pedicularineæ, by means of which bees in thrusting the proboscis into the melliferous coralline tube, cause all the pollen to fall upon their backs, which without doubt they collect with great diligence.

Thus the flowers in question, far from having dispositions tending to withdraw pollen from insects, have admirable adaptations for furnishing it to them with great speed and abundance. Nor are the flowers of Salvia, Pedicularis and Iris alone in this, but almost all those belonging to the labiate or papilionaceous types, which are characterized principally by being always irregular and more or less horizontal or pendent.

The flowers of the labiate type have the honey-food in the lower part and the pollen-food in the upper, so that insects visiting such flowers get the pollen upon their backs. To this type belong nearly all the plants which Linnæus calls *didynamous*, that is to say, nearly all the Labiatæ, Personatæ, Acanthaceæ, Lobeliaceæ, etc.

The flowers of the papilionaceous type have the position of the food curiously inverted; for the pollen is at the lower part and the honey at the upper, so that insects visiting these plants cover the abdomen and not the back with pollen. A large part of the Leguminaceæ are of this type, which is also seen in some Polygalæ, Fumariaceæ, in the genus Collinsia among the Personatæ, and in the genus Hyptis among Labiatæ, etc.

In flowers of the labiate type the anthers are guarded above by one or more petals shaped like a helmet; in those of the papilionaceous type they are guarded below by one or more petals shaped like a keel. Müller's error, which is very excusable, comes from not having well interpreted the scope or function of this protection of the anthers, which instead of keeping pollen from insects rather favors giving them the whole. And what is the purpose of this protection? It is the very important one of protecting the pollen from atmospheric agents, especially rain.

And while upon this I think it worth while to call to notice the fact that the flowers of the labiate and papilionaceous types are, at least in Europe, exclusively designed for bees, flies being too stupid to discover where the pollen and honey are, and the Lepidoptera (diurnal), which sometimes visit them not being able to open the carina or galea and thus contribute to cross fecundation. These plants, therefore, belong to that numerous class which I call melittophilous.

*In the flowers of Serapias there is a large, dark-purple protuberance, which I conjecture is designed to be attacked by some insect specially active in fecundating this plant. But in eastern Liguria, where this plant and *S. cordigera* abound, I never succeeded in surprising insects upon its flowers nor in discovering pollen-masses displaced or stigmas fecundated. But my friend Luigi Ricca, the distinguished botanist, succeeded in western Liguria in surprising a bee on *S. longipetala* with its head loaded with pollen-masses; but he did not notice whether it gnawed the protuberance or not.

One of the magnolias, *Illicium religiosum*, as I recently observed, produces in the centre of its flowers a group of very juicy *pseudostigmatic* papillæ, which doubtless furnish food to some particular Cetoniæ; which I am the more disposed to believe, as I have seen *C. aurata*, *stictaca* and others eagerly licking the stigmatic or circumstigmatic papillæ of *Magnolia grandiflora*, of which they are the real and peculiar fecundators.

In the same way the Ceteniæ, which are the normal fecundators of *Peonia montana*,

small bee, formerly noticed by Réaumur, the *Anthocopa papaveris*, cuts from the flower of the wild poppy pieces of the petal for lining the walls of its cells.

A third condition is a suitable conformation of the pollen granules and the stigmas. The pollen should be able to attach itself to the bodies of insects, and the stigmas should be able to detach it therefrom.

This affixing the pollen to the bodies of insects could not occur except by means of a spinose surface of the pollen granules, as is the case in the genera Malva and Taraxacum, or a light viscous coating as in most plants: or unless, as in the Orchidaceæ and the Asclepiadaceæ, there is a singular mechanism which attaches to the bodies of the insects the entire mass of pollen contained in the anther-lobes. Hence we see why we should not expect to find in entomophilous flowers the dry and smooth pollen of the anemophilous.*

Instead of plumose stigmas, fitted to collect pollen diffused in the air, and appropriate to anemophilous plants, we find the stigmas of entomophilous flowers smooth or papillose, but always more or less viscid.

All the many differences in colors, odors, pollen and honey, and in the structure of the pollen and the stigmas, which characterize entomophilous flowers, can be explained with entire ease if we think how infinitely varied is the mode in which the numerous phalanx of anthophilous insects can transfer pollen from one flower to another. Therefore we should not expect to find perfection reached in this or that individual flower, for we see that different plants, in their relations with insects occupy different grades of perfection, which is in entire accord with the Darwinian doc-

apparently suck by preference the red, fleshy disk (the morphological nature of which is so much in controversy) which encloses its carpels.

*Sometimes in the best pronounced entomophilous plants there is found pollen perfectly smooth, pulverulent, and light. But in these cases it is easy to account for the phenomenon. There is for instance a floral type essentially melittophilous common to the genera Borago, Cyclamen, Galanthus, etc. The flowers droop, and the connivent anthers enclose the style, forming a pyramid. The bees grasp this pyramid and pressing upon it, sprinkle the breast with pollen. It is clear that if the pollen had not been smooth and pulverulent, its discharge would not have been effected and the floral arrangement in question would be of no use.

For the same reason the pollen of *Rhinanthus* is pulverulent, smooth and dry, as it has to be scattered upon the backs of bees.

Likewise in the family of Melastomaceæ, and the genera Solanum, Cassia, Erica and others, the pulverosity of the pollen is in evident relation with the dehiscence of the anthers, having pores at their summits.

trine. It has not yet been satisfactorily shown whether or not there is any plant subject to a perennial self fecundation (selbst befruchtung), that is to say, any plant with hermaphrodite flowers where the stigmas are constantly and exclusively fecundated by their own anthers. This seems the most simple case, and was probably at first general.*

However it may be with many plants, in the case of the Ranunculaceæ, Papaveraceæ and Cruciferæ, the visits of insects effect with greater facility the impollination of the stigmas with the pollen of their own flowers (*homoclinous or homogamous impollination*) than the transfer of pollen from one flower to another (*heteroclinous impollination*).

Among primordial and homogamous plants every slightest variation which might open a way to the possibility of the transfer of pollen constituted a signal advantage; and therefore the variations of color, secretions of honey and viscosity of pollen, became fixed in the flower by natural selection. In other and more numerous cases to these simple dispositions others more complicated were added, and of such a nature as not only to favor the eventuality of heteroclinous fecundation, but render it inevitable and necessary. The sexes, for example, began to separate themselves as individuals or distinct flowers, as in the genus Salix and the

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* Charles Darwin was the first to conjecture that primordial plants were essentially hermaphrodite or monoclinous, and that diclinous plants were later and had developed unisexual flowers in obedience to the grand principle of the division of physiological labor. Frederic Hildebrand (Die Geschlichter-Vertheilung bei den Pflanzen. Lips. 1867, p. 12-14), adopts the same opinion. In a work of mine (Atti della Soc. Ital. di Scienze nat. in Milano, vol. x, 1867, p. 275-277) I exposed summarily the reasons which caused me to embrace opinions diametrically opposite. Subsequently I collected a great number of data, all which confirmed me in my views. Severino Axell (on anordningarna för de fanerogama vaxternas befruktning, Stockholm, 1869, p. 89-93) strenuously defends my opinion to which he says he was led by a process of reasoning extremely like mine but entirely independent, since he heard of my work only after his own conclusions had been reached. This coincidence gives great weight to my argument, but as it is not a suitable place to develop it here, I will only mention that the families of plants received as primordial, for instance, the Coniferæ, Cycadeæ, and Amentaceæ are unisexual and anemophilous par excellence, while those which have experienced greater evolution and are more perfect, for instance, the Ranunculaceæ, Leguminosæ, Compositæ and the Corollifloræ in general, are eminently hermaphrodite and entomophilous.

Diœcious and monœcious plants form the primordial group (essentially anemophilous); from these are then developed polygamous plants (intermediate between anemophilous and entomophilous), and from these again the hermaphrodite plants (essentially entomophilous).

This harmonizes with paleontological data; but this important generalization I reserve to develop elsewhere with a sufficient amount of facts and arguments.

Cucurbitaceæ. Here it is obvious that the transfer of pollen by means of insects is rendered absolutely indispensable. In other plants, as in *Cerastium arvense*, the Umbelliferæ and Compositæ, although both sexes are united in the same flower, yet they are not developed contemporaneously; wherefore it is equally necessary for insects to transfer the pollen from one flower to another. Finally in many other plants the flowers are formed and disposed in such a way that the transfer of pollen by the agency of insects is greatly favored and frequently even rendered necessary.

From among the great number of floral arrangements which render heteroclinous impollination necessary, and which have been brought to light by the researches of Darwin, Hildebrand, Delpino and my brother Fritz, I will mention two which not long since appeared sufficiently enigmatical, which enigma, however, has recently been solved by direct observation of the fecundating insects; I mean the floral arrangements of the Orchis of our meadows, and *Cypripedium Calceolus*.

*Orchis Morio*, *mascula*, *latifolia* and *maculata* have a spur in their flowers in the cavity of which no honey is found. This absence of honey is a phenomenon without parallel in the vegetable kingdom. Sprengel on that account called them plants with *false nectaries* (Scheinsaft pflanzen), imagining that the insects which visit them are deceived by the odors, colors and form of the spur into inserting their heads into the fauces of the flower with the expectation of finding honey. He was never able, however, to observe how the fecundating insects conduct themselves in the flowers of these Orchises. He observed, indeed, frequently, masses of pollen displaced and sticking upon the stigma, and occasionally came upon dead flies in the flowers, whence he concluded that flies are the fecundators of these plants. Nevertheless, the floral arrangement of the Orchises remained somewhat mysterious to him. "It is inconceivable to me," he says on page 404 of his work, "how it is that such flowers produce no honey, when, as it seems to me, it would be much better for them to produce it with a view to enticing flies to visit them repeatedly and fecundate them."

It is clear that Sprengel himself was conscious of not having completely deciphered the enigma. Darwin, too, as we read in his work on the Orchids, never succeeded in surprising insects in the field Orchis, although he had observed them diligently not less than twenty years. Nevertheless, he proceeds to expose in detail

the process of their fecundation, because his theory of natural selection, according to which only useful qualities can be fixed and preserved in living things, placed him in a condition to infer from simple inspection of the flowers, the details of the fecundative process.

As far as concerns the Orchis of our fields, Darwin had come to the conclusion that the insects visiting them might suck the honey enclosed between the inner and outer membranes of the spur, piercing the latter with their proboscis; that such an operation required the precise time necessary for the viscous stalks of the pollen-masses to attach themselves firmly upon the heads of the insects; and that the time occupied by the pollen-masses securely attached to the insects in becoming depressed upon their stalk so as to be able to rub against the stigma, corresponds nearly to the time employed by the insects in visiting one plant and passing to another. In this way, intercourse between two individuals would necessarily take place.

However, when we consider the immense number of such Orchids in the meadows, and reflect that insects have to perform several operations in order to fecundate them, it seems strange that they should never have been surprised at work by any one. Fortunately, I am able to fill up this gap and at the same time fully confirm Darwin's conclusions.

Towards the close of last spring I had taken a good many Bombi and some honey bees with several masses of pollen upon their heads, and I saw a *Bombus sylvarum* fly to the flowers of *Orchis Morio*, stick its proboscis into the spur and fly away with pollinaria upon its head. On another occasion, I saw at a distance a *Bombus lapidarius* fly to the flowers of *Orchis latifolia;* and I also saw a dipterous insect, *Volucella bombylans*, with the pollen-masses of *Orchis maculata* upon its head. However, during the spring I was not able to observe these insects closely enough to note exactly their movements and deportment.

But subsequently, on the sixth of this month (May, 1869) upon the heights of Stromberg, very abundant in Orchis, both I and my son Hermann were enabled with ease, and close at hand, to observe many Bombi at work. At a place full of *Orchis mascula* we saw a Bombus which appeared to be *B. terrestris* fly to the lowermost flower of a spike of this Orchis. It inserted its head into the flower, remaining about four seconds, and then withdrew it with

two pollen-masses attached. Ascending from the bottom towards the top, it visited the second and third flowers of the same spike. After withdrawing its head from the third flower, it stopped a short time and endeavored to brush off the pollen-masses with its legs, but without success. It then continued its visit, climbing up the spike, and visited a fourth flower. At this point I tried to catch it in the net, but failed, and it flew away. After standing a short time we saw a *Bombus hortorum* visit three or four flowers from base to summit of a spike of *Orchis mascula*, after which it flew to another individual of the same species, visiting its flowers in the same way. Upon examining the stigmas of this second individual we found pollen scattered upon them, and the anther lobes emptied of their pollen-masses. In the space of about two hours, which we spent in observing this fecundation of *Orchis mascula*, we noted two visits of *Bombus lapidarius* and one *Psithyrus campestris*. The *Bombus lapidarius* did not remain in the flowers longer than from two to three seconds. We captured the *Psithyrus* and one *Bombus lapidarius*. Both had a quantity of pollen-masses upon their heads, some of which were already depressed upon their respective stalks, and therefore in a condition to rub against and fecundate the stigmas, while others were yet erect and therefore not in a condition to effect fecundation. Of ninety-seven bees collected by us in this excursion, thirty-two had pollen-masses stuck upon their heads. Sometimes we observed that the bees succeeded in freeing themselves from some of the pollen-masses, either by tearing them off with their mandibles or brushing them off with their fore-legs. Possibly, it is in this way that sometimes in the flowers of Orchis, pollen-masses are found in greater or less proximity to the stigma, out of place and, as it were, wasted.

At least a good third, then, of the bees collected on the heights of Stromberg were engaged in the fecundation of Orchises, and we can obtain an approximate measure of their activity by the following figures. At seven o'clock, A. M., in a meadow containing several thousand individuals of *Orchis mascula*, I collected ten spikes which had one hundred and seven open flowers, only three of which had the stigma smeared with pollen, and one alone was without pollen-masses. Towards five o'clock, P. M., I collected from the same meadow ten other spikes having ninety-seven flowers open. Fourteen of these flowers had the stigmas smeared with pollen, two of which still preserved the pollen-masses in

place while the remaining twelve no longer had any. Two had a couple of pollen-masses stuck upon the edge of the stigma, and three were without any pollen-masses at all though the stigma was devoid of pollen. Thus at seven o'clock in the morning the fecundated flowers were in the ratio of two and one-half to one hundred, and at five o'clock in the evening the ratio had reached fourteen to one hundred.

Thus the conclusions of Darwin are fully confirmed by my observations. The bees must seek something in the spur of the flower or else they would not stop to visit them repeatedly. Since the honey is not free in the interior of the spur but is contained between its inner and outer membranes, the insects have to pierce this latter, which is very delicate and cannot offer the least difficulty.* Direct observation has shown that a stay of three or four sec-

* My studies thus far made upon field Orchis would lead me to different conclusions from those of Darwin and Müller. In the acts of the Italian Society of Natural Sciences of Milan (vol. 12, 1869, p. 129) I said: "this asserted deficiency of fecundation, together with the phenomenon of the absence of honey in many species of Orchis which have an enormous development of an *illusory* spur, *formerly* honey-bearing but now dry, produces the conviction that such Orchids are degenerate forms and more or less near extinction.

There is here a manifest example of imperfection or rather, organic degeneration, the pernicious effects of which are very obvious if we compare the scanty number of capsules in orchids, with the abundant fructification of *Spiranthes autumnalis*, *Loroglossum secundiflorum* and other Orchids which secrete a sweet fluid."

Darwin and Müller suppose that there is a secretion of nectar between the inner and outer membranes of the spur. Now, in all my observation, I never could see this honey. I indeed saw frequently, but not always, that the inside of the spur is vesicular, but when examined by the microscope I found that there is absolutely no trace of that glandulose tissue which is a constant characteristic of nectar-producing surfaces. Besides, reasons deduced from close analogy are against such a condition of things. Gymnadenia and Platanthera, which are closely related to them, have a spur entirely analogous to that of the Orchids, yet the honey they produce is not secreted in a vesicular hypodermis, but transudes in a normal manner.

I willingly admit that some liquid is frequently met with in such pores. In the vesicular parts of plants, e. g., in the summits of the inner petals of Dielytra, in the bladdery fruits of Colutea, Vesicaria, etc., drops of liquid are found, but these are only water of transpiration, or rather lymph, but never honey. It may happen that this lymph, which was found in abundance by Darwin in *Orchis pyramidalis* alone, really attracts *Acontia luctuosa* (one individual of which was found with its proboscis loaded with seven couples of pollen-masses), and other diurnal and nocturnal lepidoptera. But on the whole it seems improbable to me that the spurs, although lymphatic, yet not honey-bearing, of *Orchis morio*, *latifolia*, *maculata*, etc., should attract bees.

But bees, according to the positive observations of Müller, frequent and fecundate the flowers of Orchis. This fact signifies, according to my view, that they resort to them for some other purpose, which is to collect pollen which they find already prepared in a convenient form. It is more than probable that upon entering their hives loaded with bundles of pollen, they are soon freed by their companions from the annoyance they experience.

Sprengel calls the spur of Orchis a false nectary. Although in some plants I have

onds is sufficient to stick the pollen-masses firmly upon the heads of the insects, and any one can easily convince himself of the fact by introducing into the flower a sharpened pencil, and holding it for three or four seconds when, upon withdrawing it, pollen-masses will be found adhering to it. It will also be found that in about forty seconds after drawing it out, these masses will have completed that movement of declination by virtue of which they can come in contact with the stigma. Now, as a bee, from what we observed, does not remain on a given spike longer than twenty or twenty-two seconds, it is clear that it cannot fecundate it with its own pollen, but only with that of spikes previously visited.

On the 11th of May, 1869, in the neighborhood of Lippstadt near Overhagen, I repeatedly saw bees effecting the fecundation of *Orchis latifolia*, but I observed nothing new, or in any way different from what I noted in the case of *Orchis mascula*.

Towards the close of last year I published in the acts of this Society an observation made in May, 1867, upon the fecundation of Cypripedium, which was in many respects incomplete because made under unpropitious circumstances, although I succeeded with the aid of the Darwinian theory, in completely explaining the part the different floral organs play in securing the fecundative process. But on the 16th of May, 1868, in the same locality, I was able to make a greater number of observations, and confirm all my conclusions. This place which was of limited extent had only six flowers of Cypripedium. Passing and repassing in the examination of the slipper-like flowers peculiar to this plant, I found in one of them, which half a minute before was empty, an *Andrena pratensis* which by its violent agitation could be perceived at the distance of several feet. Visibly disquieted by its imprisonment it tried at least twenty times to climb up the walls of the slipper, but these are so contorted, and of such a shape, that after every attempt the Andrena slipped back again into the flower. Finally, it retired to the base of the flower and pushed its head into one of the two small apertures there; but this being too narrow, it attempted to scale the walls anew, and not succeeding, ran back

come upon organs or parts of organs, which really merit this appellation, it does not seem to me applicable here. I ascribed to Orchids an illusory spur, once perhaps honey-bearing, but now dry, and I think that is the better view. It is in favor of this view that orchids, at least in eastern Liguria, are almost entirely passed over by insects, and offer an incredibly small number of transformed pollen-masses and fecundated ovaries.

again to the small aperture, and then again climbed up with no better success than before. Then, after a short pause, it ran with greater impetus to one of the small apertures (to the left) and using all its strength, at length succeeded in pressing down the lip and pushing its head, thorax, fore legs, and finally its whole body through this aperture, and so was again at liberty. In this passage, its right shoulder rubbed against the anther overhanging the aperture and carried away a good deal of the pollen.

The flower of Cypripedium, then, must be considered as a trap for Andrenas which enter it, allured by a sweet exhalation, and the minute drops of honey exuding from the apices of certain hairs in the lip. If an Andrena visits this snare during the warmer hours of the day, that is to say, when it possesses its maximum vital energy, it easily succeeds after a few minutes in freeing itself from its prison, but not without first getting some pollen upon its back which will fecundate the stigma of the next flower it visits. But if it is caught in the cool of the evening, it must perforce make up its mind to take lodgings there for the night, and be content to escape from its unwelcome quarters during the warm hours of the next day.*

If small Andrenas falling into this trap have not strength enough to push aside the lip so as to escape through the small apertures,

*The structure of the flowers of *Cypripedium* relatively to the mode in which promiscuous intercourse is effected by means of insects, has been studied, in order of time, by Charles Darwin, Asa Gray, by myself, and by E. Müller.

Darwin (On the Contrivances, . . by which . . Orchids are fertilized by Insects) believed at first that the fecundation of the species of this genus took place by means of the proboscis of certain insects which, in being introduced by one of the two small holes of the sac, became covered with pollen which was then communicated to the stigma.

Gray soon after, from an examination of some American Cypripedia concluded that fecundation was effected by small insects entering the flower by the large opening, and leaving it covered with pollen by the small ones.

In 1866 I examined some exotic Cypripedia in Florence, and, though ignorant of Gray's observations, reached the same conclusion (On the arrangements for fecund. of anthoc., plants 1867, p. 20, 22).

The next year E. Müller (Beobacht. an West fälisch. Orchidera p. 1–6), established the truth of my conjectures, observing and describing the mode of action of certain andrenas in visiting and fertilizing the flowers of *C. Calceolus*.

In 1868 and 1869, having had occasion to study anew the flowers of some foreign Cypripedia (*C. barbatum* and others), I observed the manner in which large flies are imprisoned in them. It should be noted that not unfrequently in the Boboli botanical gardens the ovaries of Cypripedia ripen, without doubt, in consequence of the visits and imprisonment of these flies.

Ultimately Darwin (notes on the fertilization of Orchids, 1869, p. 16 and 17) cited the observations made on Cypripedium by Gray, myself, and Müller, fully admitting the results.

they die with hunger; and on the 17th of May, of this year (1869) I saw two dead individuals of *Andrena parvula* in the flowers of Cypripedium.

I here leave the first part of my subject, the application of the Darwinian doctrine to flowers, and pass to the second, which is the application of the same doctrine to the insects which visit the flowers.

As flowers are accommodated to the visits of insects, and as the meaning of the structure of flowers can only be comprehended by thoroughly knowing their entomological relations, so the insects which derive nutriment from flowers are accommodated to them, and the structure of their bodies cannot be well understood except in the relation of adaptation to flowers. And since, according to the Darwinian doctrine, the adaptations of insects to floral food can only be considered as characteristics slowly acquired by hereditary descent, we are necessarily led to distinguish inferior or primitive, and superior or posthumous forms. We are thus led to some indications of a genealogical tree of the insects which visit flowers.

These insects belong principally to three orders, the Hymenoptera, Diptera and Lepidoptera. The incentives, however, which urge them to visit flowers are different for each. The Lepidoptera suck honey exclusively; the Diptera devour pollen and are in the habit of sucking not only honey, but any sort of liquid; and, finally, the Hymenoptera which visit flowers, that is, bees, feed exclusively on honey and pollen, not only in their perfect state, but also as larvæ, so that they suck honey, eat pollen, and collect both for their young.

Of the three orders cited, that of Lepidoptera is the only one which is composed of families all of which are adapted to floral food, although only in the perfect state. Hence, it is that their buccal organs have a very uniform structure. The labrum and mandibles are entirely atrophied;* the maxillæ are transformed into two tubular [nearly], cylindrical and spirally twisted filaments which perform the function of a sucking tube; and at the base of these filaments are two rudimentary palpi. The inferior lip or labium is atrophied, and as a compensation its palpi are greatly developed.

*Their rudiments are readily seen, except in certain silk-worm moths, in which the labrum is entirely atrophied. — EDS. NATURALIST.

If we turn from those Lepidoptera, which, endowed with a long proboscis, hover without alighting, and suck honey from the bottom of flowers with the longest tubes, and regard those which are of an inferior grade of adaptation, we find all possible gradations from a long proboscis to a rudimentary one, where the buccal parts are yet recognizable under the form of small fleshy papillæ equally unsuited either to bite or suck. According to the Darwinian doctrine, all Lepidoptera are derived from a single stock, and their characteristic spiral proboscis must have been formed gradually by slight and innumerable variations, which in the struggle for existence, were advantageous to those individuals in which they appeared, and were, therefore, able to accumulate and become fixed in their posterity in accordance with the laws of hereditary transmission. Therefore, as a necessary consequence of this doctrine, we should expect to find that the order Lepidoptera offers in its lowest stage this characteristic of a spiral proboscis, and possesses those fleshy protuberances or rudimentary buccal organs which we see to-day possessed by not a few of its representatives. This conjecture, strictly deduced from the Darwinian doctrine, accords wonderfully with the opinion of entomologists of great authority, who admit that there is the closest affinity between the Phryganeidæ and Lepidoptera; and the Phryganeidæ have the buccal organs precisely in that rudimentary state which we should pre-suppose appropriate to the primordial race or type of Lepidoptera. And, further, to consider this affinity of the Phryganeidæ with butterflies, Réaumur deduced it from general considerations upon the analogies of the insects; De Geer from the analogous form of the wings, and from the internal structure of the larvæ; Kirby from analogies in the buccal organs, and Westwood from the habits of the case-bearing larvæ of the genera *Psyche* and *Tinea*, from the analogous covering of the wings in the Phryganeidæ and some Papilios, and from the tibiæ analogously spinose in the two groups.

The expression, "*close affinity*," employed by these entomologists is changed and resolved, in the language of the Darwinian doctrine, into *close relationship*, and signifies that both Lepidoptera and Phryganeidæ proceed from a single stock, which, both in the internal structure of its larvæ and their habit of dragging a sheath about with them, in the venation and covering of the wings, the spinose character of the tibiæ, the buccal organs reduced to fleshy

protuberances, and in the long antennæ, would quite closely resemble the Phryganeidæ of to-day. The posterity of this stock separated into two parts. One of these continuing to live either in, or near the water, diverged little from the primitive customs, habits and forms, and came to constitute the group of Phryganeidæ. The other accustomed itself to suck the honey of flowers, withdrew itself little by little from the water, and, finding its new diet entirely acceptable, adapted itself to it completely, modifying the buccal organs, step by step, by successive variations always more convenient and more in harmony with its new mode of life, until in this way it gradually acquired a proboscis sufficiently long and dexterous to suck honey. It moreover, greatly developed its æsthetic sense of colors, at first in correspondence with the lively coloring of the flowers, and then in reference to sexual election. As soon as the hairy system of wings and body began to vary, which can happen the more easily the greater the surface of the hairs themselves becomes, until their complete conversion into variously tinted scales, the females would prefer those males which were adorned with the liveliest colors, and, vice versa, the males would select the most brilliantly adorned females.*

* The relations of colors and odors which occur between flowers and their fertilizers, may to many appear a chimerical product of the imagination. But after a long series of observations I can assert that, however unexpected and surprising they may be, they are yet undeniable and real.

It is believed by many that the æsthetic sense belongs only to the human race. Nothing is more erroneous. The sense of music alone, however much it has been and perfected in birds through sexual selection, is beyond comparison more perfect in man. In the senses of taste and smell man is, by a singular coincidence, like bees and butterflies. Sweet things please our young not less than bees, and the ancient poets designated with the same word, nectar, the food of the gods and the honey of bees. By a no less singular coincidence the odors which allure bees and butterflies allure us too, and those which repel us repel bees. The graveolent flower of rue, which is so excessively disagreeable to us, although visited by flies, repels bees and Lepidoptera although it produces honey.

As to the æsthetic sense of colors and form, then, if we speak the plain truth, man is inferior to many living things.

Passing in review the most beautiful forms, and those adorned with the most attractive colors, we have on one side flowers, and on the other their fertilizers, that is, birds, flies, humming birds, Nectarineæ, lepidoptera, Bombylii, Syrphidæ and some Cetoniæ.

The most beautiful forms and brilliant tints in the world are without question those of the humming birds. They visit the most splendid and beautiful flowers on the earth, and the reason why the magnificent flowers of the tropical zone do not enter our climate is certainly correlative to the causes which exclude from temperate and cold countries the humming birds and gorgeous lepidoptera which are peculiar to warm regions.

But not all flowers are beautiful; there are some which have livid and repulsive

As to flies, it has been until now generally admitted that they are exclusively destined to fluid nutriment. But in the summer of 1867, I was somewhat surprised while observing in my garden an *Eristalis tenax* upon a flower of *Œnothera media*, to discover that it was eating the pollen. Resting upon its middle and hind legs, it thrust out its fleshy proboscis like an arm, seized a morsel of pollen with the two valves which terminate the proboscis, and tore it away from the anther. Since the pollen granules of Œnothera are tied together by elastic threads, that bit of pollen torn from the anther was attached to others by a band of threads, and the insect, in order to free its mouth from that inconvenient appendage began to use its fore-legs. Raising both together towards its mouth, it seized between them the cordon of threads, and rapidly rubbing them one against the other, much as we do in washing our hands, succeeded in cutting the threads and clearing them from its mouth and legs. Then it raised them again, and seized the two valves of the proboscis, thoroughly cleaning them of pollen, and the threads yet adhering to it; and in about three seconds this work of cleaning was complete. At the same time the valves of the proboscis, by rubbing against each other, had masticated the morsel of pollen, and had conveyed the single granules into the channel of the labium, whence they were pushed into the mouth. It had hardly finished cleaning its proboscis and eating the first mouthful of pollen, when it seized another portion and repeated each and all the operations I have described. It was so intent upon its meal, that I was able to observe it in the closest proximity without its manifesting the slightest fear.

The quantity of pollen which an Eristalis can devour in this way is surprising. Upon making a section of one and examining

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colors. Nor do all flowers emit a pleasant odor, since some have a fetid smell, or one like that of decaying animal matter.

All the flowers which have this (those, e. g., of Arum, Dracanculus, of the Stapeliæ, of some American Aristolochiæ, of the Rafflesiæ, Sapriæ, Brugmansiæ, Sapranthus, etc.) have without exception livid colors, and, like the skins of some serpents, are speckled with dark-purple and yellowish-black spots. Now all these flowers are fertilized exclusively by the flies which feed upon dead animals (*Sarcophaga carnaria*, *Musca vomitoria*, and the like).

The flowers of the Ceropegiæ, one *Aristolochia*, *Asarum*, and *Ambrosinia Bassii*, are fecundated exclusively by gnats (Phora, Ceratopogon, Cecydomya, Oscinis, etc.). All these have a generally livid tint speckled or striped with dark-purplish spots, and a putrid odor, for the most part like that of urine.

These few instances suffice to give an idea of the wonderful relations which occur between flowers and their fertilizing agents with reference to colors and odors.

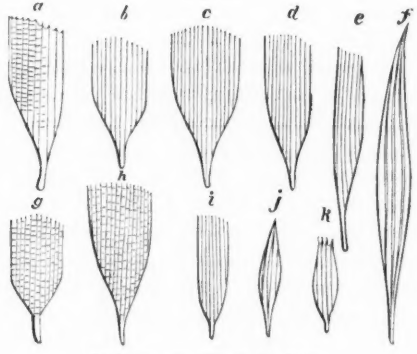
the stomach, it appeared very large and was full of a yellow substance which consisted of hundreds of thousands of pollen-grains. I have had since then many opportunities to observe this eating of pollen, not only in all the species of Eristalis, but also in the genera Rhingia, Syrphus, Volucella and Scatophaga. This chewing of pollen alternates with sucking honey if the flowers have any, and I am of the opinion that the singular structure of the proboscis of flies cannot be fully explained without taking into account its double function of sucking honey and eating pollen. In the Tipulariæ and also in those flies which do not eat pollen but live exclusively upon juices, for instance, Bombylius, the two valves of the proboscis serve no other purpose than to protect and guide the sucking tubes, but in the flies which devour pollen besides this function there is also that of grinding the pollen, for which they have special adaptations, for the margins of the two valves at the point of union are transversely dentate with fine and parallel bands of chitine. Probably the greater or less distance of these bands in different species is related to the different size of the pollen upon which they feed.

Since the proboscis of the Tipulariæ often possesses one simple function and has in accordance with that a very simple organization, we may consider these Tipulariæ as the most ancient branch of the stock from which Diptera are derived. A fact casually discovered by me and of which I find no mention hitherto, seems to me of great importance in the systematic disposition of this order. In the spring of 1868, while engaged in examining the head of a gnat, with a view to ascertain whether or not the valves of its proboscis had the transverse bands of chitine, I was surprised to discover that the proboscis and palpi were clothed with scales entirely like those of butterflies.

I find no mention of this important fact in the special works of Meigen and Schiner which are in my possession. Meigen simply points out that in Culex, Anopheles, and Corethra, scaly productions are observed on the venation of the wings, and he figures some of them which, however, being quite narrow and with two sharp points, have no analogy with real lepidopterous scales. The gnat-scales observed by me and figured accurately (fig. 73) closely resemble the most characteristic lepidopterous scales. They suddenly dilate from a short and narrow peduncle to a large scutiform surface which is traversed longitudinally

by a few parallel ridges between which, when more highly magnified, transverse wavy lines, very fine and numerous, are seen. The only difference which these scales present compared with those of butterflies is, that in the former the transverse lines are not so fine, so regular, nor so regularly distributed over the whole surface; also these lines are entirely wanting upon the scales of some species of Tipulariæ. Finally, while the real lepidopterous scales are always deeply crenate at their truncated extremity, the scales of gnats are not; and their truncated extremity terminates in a very fine margin, from which the points of the longitudinal ribs sometimes project.

Fig. 73.




Scales of two species of *Culex*.

*a*, *e*, Scales of the veins of the wings.
*j*, *f*, " " " margins of the wings.
*i*, *g*, " " " legs.
*b*, *c*, " " proboscis and palpi.
*d*, *k*, *h*, " " " of the second species of *Culex*.

These scales are partly dark and opaque, partly colored and transparent. It is in the latter that the transverse striæ frequently appear. All the figures are magnified 400 diameters.

I have examined several species of gnats and have found the proboscis, palpi, legs and abdomen clothed with scales of the same sort, while the thorax and the veins of the wings had forms intermediate between hairs and scales. I observed this in a magnificent Tipula from Brazil given to me by my brother Fritz. Besides this it had as a particular ornament a long tassel of scales upon its legs.

The presence of these scales upon the Tipulariæ shows that

there is a close relationship between them and Lepidoptera, a relationship which is further attested by the lepidopterous appearance of the genus Psychoda, the tipulaceous habits of Pterophorus, the similar venation of the wings in many Tipulariæ (Limnobia, Ctenophora,) and the Phryganeidæ, the aquatic habitat of the larvæ of the Tipulæ, and, finally the circumstance that it is far easier to deduce morphologically the proboscis of the Tipulæ from the buccal organs of the Phyganeidæ than from those of any other order of insects.

Therefore, according to my opinion, the stock or kindred common to the Diptera, Lepidoptera, and Phryganeidæ, in its manner of life, and the structure of its body would be very closely allied to the Phryganeidæ of to-day, living in water in the form of sheath-bearing larvæ, and in the perfect state remaining in the vicinity of the water. Its posterity divided at first into two branches, to wit, the *conservative* one *par excellence*, of the Phryganeidæ, which continuing in the same mode of life as its ancestors, has undergone very few variations; and the branch of those insects which suck the honey of flowers, which have gradually removed from their aquatic abode, have developed by natural selection the sense of colors, and acquired through sexual selection a squamose covering. This second branch again divided into two, one of which accustomed itself to feed exclusively upon the honey of flowers and produced Lepidoptera; while the other, less exclusive in its tastes adapted itself to imbibe all sorts of fluids as well as to pierce the more tender tissues, and produced the Tipulariæ. One part of these besides sucking different juices, grew accustomed to eating pollen and thus little by little the proboscis of the Tipulæ was transmuted by natural selection into that of flies equally well adapted to suck honey or eat pollen.

The Hymenoptera which visit flowers, the bees, being given exclusively to floral food not only in the perfect state but also while larvæ, present the greatest possible variety of adaptation. Starting from the mouth of the fossorial Hymenoptera adapted only to bite and provided with a very short tongue, we arrive, through numerous transitions, to the highly developed proboscis of the Anthophoræ and Bombi which can extrude their tongue to a length equal to that of their body, and then coiling it up, draw it back again into its cavity so as to give free play to the action of the mandibles. Furthermore, in different ways, according to the

different species, this or that part of the body has undergone special adaptations so as to be able to collect pollen with greater ease and in greater abundance. A sure criterion by which to comprehend these differences thoroughly as well as to estimate correctly the different grades of affinity between forms so varied, can be given only by the Darwinian doctrine. But we have no space to particularize.

We will conclude by discussing some objections which can be urged against the explanations of facts, and against the general principles advanced in this discourse.

It may be asked, what advantage can flowers and insects derive from having elongated respectively the melliferous tube and the proboscis instead of having them remain of a constant length? I answer that in order to comprehend the advantage of this elongation, it is necessary to consider in one view the benefits and the injuries which different tribes of insects bring to plants. The Lepidoptera are the only insects which, while aiding the plants by transferring pollen from one flower to another, do not cause injury by devouring the pollen. Therefore a plant which has modified its flowers so as to exclude bees and flies while admitting Lepidoptera, has obtained a signal advantage.

Suppose a plant develops a floral tube longer than usual so that the honey remains at a lower level; this variation will be an advantage for that tribe of insects which lives on honey alone and can therefore adapt itself more diligently to this variation. The advantage in this case is for the Lepidoptera and will last until the proboscis of certain bees and flies equals that of the Lepidoptera. When this equalization has been completed, a further elongation of the floral tube will be useful to the plant, which will immediately be followed by a corresponding elongation of the proboscis of the Lepidoptera, and so on. In this way, by means of the rivalry between the Lepidoptera, bees, and flies, the fact that the Lepidoptera do not consume pollen and can sooner adapt their proboscis to the variations of the flowers than their rivals coöperating, a gradual augmentation in the length of the tubes and spurs of flowers would become established, followed by a proportional elongation of the proboscis, concomitant in the Lepidoptera, later in bees and last of all in flies. It may be well to give in this place the measure of the longest proboscides of some of the Lepidoptera, bees and flies of our country.

Among flies the proboscis of *Bombylius discolor* is 10 millimetres long; that of *Rhingia rostrata* from 11 to 12 mm.; among bees that of *Bombus hortorum* is 21 mm., and that of *Anthophora pilipes* 25mm.; the proboscis of *Sphinx Elpinor* among the Lepidoptera is from 20 to 24 mm. long, that of *Sphinx pinastri* from 28 to 32 mm., and that of *Sphinx ligustri* from 37 to 42 mm. But the longest proboscis is that of *Sphinx convolvuli* which is from 70 to 80 mm. This exceptional size led me to infer that *Sphinx convolvuli* may have acquired its long proboscis by competition with the flies and bees with a long proboscis inhabiting warm climates. This conjecture is confirmed by information as to the geographical distribution of *Sphinx convolvuli* afforded me by Dr. Speyer.

In order to eliminate the visits of bees and flies which prey upon pollen and permit only those of Lepidoptera, a variation still more advantageous than the elongation of the melliferous tube is manifestly that of flowering at night. And this is precisely what many plants do, which keep their flowers closed during the day and open them in the evening when with the disappearance of the sun the activity of bees and flies is entirely destroyed. It is in the hours of the evening and night that the flowers of such plants by the brilliancy of their colors and the pungency of their odors attract sphinxes and other moths, showing in an eloquent way how advantageous to themselves is the preference they show for the visits of insects which are only useful to those of insects which are at the same time useful and hurtful. But it will be said; why cannot bees and flies as well as Lepidoptera adapt themselves *pari passu* to the noctifloral variations of plants? It is not difficult to see why. Lepidoptera feed only upon honey, and hence are obliged to follow *pari passu* the variations of the plants which nourish them with analogous variations on their part. Flies, however, do not live exclusively upon honey, but suck by instinct any sort of liquid, and bees after collecting honey and pollen have to make complicated manipulations in the hive. Whence it is plain why Lepidoptera only and not bees and flies as well, can acquire nocturnal habits, and adapt themselves to night-flowering plants.*

* However ingenious and seductive may be the theory here developed by the author to explain the genesis of evening or nocturnal flowers, and of flowers with a long, honey-bearing tube, it nevertheless seems contradicted by a multitude of facts collected by me, and by arguments which I here briefly subjoin.

The whole theory of the author reposes upon the fact that Lepidoptera do not feed

There is yet a general objection which can be advanced against the application of the Darwinian doctrine to flowers and insects. Even conceding, it may be said, that this doctrine can be applied to all the phenomena of the organized world, and that in many points its *a priori* deductions are confirmed *a posteriori* by observation, it does not follow from that that it should be preferred to the teleological mode of view which explains every property of organisms as created with a view to the well-being of a given individual or of other individuals as well.

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upon the pollen, and that their visits are consequently of greater utility to plants than those of bees and flies.

If the theory is in harmony with truth the following phemonena would necessarily be verified.

First, the flowers fecundated exclusively by Lepidoptera, that is, evening or nocturnal flowers, as contrasted with flowers fecundated by bees or flies, would constantly manifest a considerable saving in the production of pollen. Let us see if this saving takes place in the conspicuous examples of night-flowering plants. *Mirabilis jalapa* and *M. longiflora* for every ovule to be fertilized offer not less than five anthers furnished with numerous pollen-grains. *Œnothera biennis*, furnished with eight large anthers, offers to the proboscis of the Lepidoptera festoons of pollen, the greater part of which is of use neither to the insects nor the plant. *Cereus grandiflorus* has an excessively large number of stamens and consequently of pollen. Striking a mean of these and other lepidopterophilous flowers and comparing it with a mean of melittophilous flowers it must be admitted that there is not the least appearance of pollen-saving in the former.

Secondly, the flowers with long tubes, or those fertilized *preferably* by Lepidoptera or Trochili, if the author's theory is true, would constantly harbor the anthers within the tube so as to withdraw them from the depredation of bees and flies. Now this is precisely what does not occur in the great majority of such flowers, the anthers of which protrude beyond the tube, evidently to make bees and flies, as well as Lepidoptera, contribute to the transfer of pollen. This form of flowers, which can be said to be absolutely wanting to the flora of Europe, is, however, frequent in tropical plants.

Thirdly, if the theory in question is true, plants with flowers exclusively lepidopterophilous would take, or would tend to take, the advantage over plants with exclusively melittophilous or myophilous flowers. But precisely the opposite of this is true, and, limiting myself to European flora, while not more than from ten to twenty species are exclusively lepidopterophilous (species of *Pancratium*, *Calystegia*, some Caryophyllaceæ, and the like), the exclusively myophilous species are numerous (almost all the Umbelliferæ, Rhammaceæ, Aristolochiaceæ, Euphorbiaceæ, Celastrineæ, etc.), and most numerous of all are those which are exclusively melittophilous, that is, all the Leguminosæ and the greater part of the Labiatæ, Personatæ, Borragineæ, Cynarocephalæ, Lactucæ, etc.

From all this we conclude that the theory of the author of the genesis of lepidopterophilous flowers, although ingenious, does not seem admissible. I am as profoundly pursuaded as Erm. Müller that both the possession of long, honey-bearing tubes, and the habit of flowering at night in plants, stand in a causal relation with the Lepidoptera and their proboscis; but not that the reason of this reciprocal adaptation only has to do with the greater or less depredation of pollen on the part of the insects; since it must be referred to other contingencies.

It would seem opportune to state the result of the studies I have made with a view to elucidate the genesis of lepidopterophilous flowers; but as this special theme is connected with the whole theory touching the genesis of anemophilous, ornithophilous, melittophilous, etc., flowers, I am constrained to refer to my other writings, as there is no space here to enlarge.

Without stopping to mention that every teleological explanation involves an absurdity inasmuch as it suppresses in the order of the phenomena the bond between cause and effect, I will here briefly adduce some facts which render the acceptance of the doctrine of final causes impossible. I have already touched upon the errors into which Sprengel fell in thinking that the arrangements in flowers were so disposed for the benefit of insects. Nor can a single example be adduced of a living being whose properties are advantageous to other species and not to its own.

The other supposition then, that every property of individuals has been created for their well-being, in the greater number of instances answers as well for the interpretation of phenomena as the Darwinian system. But there are cases in which it does not answer at all. The abortive stamens and the anthers without pollen in some flowers of Glechoma, Thymus, and other polygamous Labiatæ, the tibiæ of Apathus dilated like those of Bombus, although the former do not collect pollen, the retrorse teeth of the sting of bees which cause the death of those insects if they use it, are a few examples drawn from an inexhaustible mine of facts, all easily explained by the Darwinian doctrine, and inexplicable by the teleological.

All the numerous instances where the functions and conditions of life have been changed in such a way that many of the inherited properties become of no use or even injurious, offer an insoluble difficulty to the teleological doctrine, while they are in full harmony with the Darwinian theory.*

* I must here, as always, declare myself a teleologist and vitalist. Now teleology and vitalism, far from being vanquished by the Darwinian doctrine, find in it their most solid support. What do teleology and vitalism mean? They mean that we believe that there is in all living things an innate, specific principle, intelligent, free and teleological. This principle is the hidden cause of the variability of organized beings, as well as the wonderful harmonies which have been established between one being and another.

Every man is conscious of proposing continually a determinate end for his actions and of seeking the best means for attaining it. Therefore, every man is free and teleological; and every man has the profoundest conviction of this fact, nor can all the sophisms of the materialists of the present day against human liberty stand against the verdict of consciousness. And if man is teleological and free, how can other living things, each in its proper sphere, which are united to him by a more or less remote relationship, not likewise be free?

Man and other living beings vary because they are free, and are free because, if they had not varied they could not have been free; if they had not been free, they could not have varied. Liberty and variability are inseparably conjoined. The different worlds, stones, and crystals obey fixed, indeclinable, mathematical laws. Therefore they do not vary. They are not free because they do not vary, and do not vary because they

# A NEW SPECIES OF ERYTHRONIUM.

BY PROFESSOR ASA GRAY.

ORDINARILY it is hardly worth while to make a separate article for a single new species of plant, even when discovered in a district in which a new flowering plant is unexpected. But the species of *Erythronium* are so few, and the present one is so peculiar, and its habitat so closely bordering the region included in my Manual of the Botany of the Northern United States, that I need not apologize for bringing it at once to notice.

The specimens before me, accompanied by a colored drawing, are just received from Miss S. P. Darlington (a daughter of the late Dr. Darlington, long the Nestor of American botanists and one of the best of men), and were collected at Faribault, Minnesota, by Mrs. Mary B. Hedges, the teacher of Botany in St. Mary's Hall, a school of which Miss Darlington is Principal.

The flower is much smaller than that of any other known species, being barely half an inch long; and its color, a bright pink or rose, like that of the European *E. Dens-Canis*, reflects the meaning of the generic name (viz. red), which is lost to us in our two familiar Adder-tongues, one with yellow, the other with white, blossoms. The most singular peculiarity of the new species is found in the way in which the bulb propagates. In *E. Dens-Canis* new bulbs are produced directly from the side of the old one, on which they are sessile, so that the plant as it multiplies forms close clumps. In our *E. Americanum* long and slender offshoots, or subterranean runners, proceed from the base of the parent bulb and develop the new bulb at their distant apex. Our Western *E. albidum* does not differ in this respect. In the new species an offshoot springs from the ascending slender stem, or subterranean sheathed portion of the scape (which is commonly five or six inches long), remote from the parent bulb, usually about mid-way be-

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are not free. Invariability and necessity are inseparably united. Opposed to worlds, crystals, and all inanimate matter, which is neither free nor variable, there appears a phalanx of beings both free and variable. It is, then, perfectly logical to presuppose in these last a principle peculiar to them and *sui generis*, the animistic principle, and it is entirely illogical to deny it.

Thus we see how Teleology extends the hand to Darwinism, and both doctrines, illustrating and supplementing reciprocally, mutually support each other.

Fig. 74.

*Erythronium propullans* Gray.

tween it and the bases or apparent insertion of the pair of leaves: this lateral offshoot grows downward, sometimes lengthening as in the foregoing species, sometimes remaining short, and its apex dilates into the new bulb.

This peculiarity was noticed by Mrs. Hedges, the discoverer of this interesting plant, to whom great credit is due. Most lady botanists are content with what appears above the surface; but she went to the root of the matter at once. I learn that *E. albidum* abounds in the same locality. *E. Americanum* is also found in the region, but is scarce.

It is not easy to find or frame a specific name which will clearly express the most remarkable characteristic of this new species. But I will venture to name it

ERYTHRONIUM PROPULLANS.— E. scapo infra folia pullulante; foliis oblongo-lanceolatis acuminatis parum maculatis; perianthio roseo-purpureo (semipollicari), segmentis acutis basi luteo tinctis omnino planis (nec calloso-dentatis nec sulcatis); antheris oblongis; stylo fere equabili integerrimo; stigmate parvo vix tridentato; ovulis in loculis 4–6.

Scape bulbiferous from its sheathed portion below the developed leaves; these oblong-lanceolate, acuminate, slightly mottled; perianth rose-purple or pink (half an inch long); the segments acute, all with a yellow spot but plane at the base, the inner like the outer destitute of either groove or tooth-like appendages, but a little more narrowed at base; anthers merely oblong; style hardly at all narrowed downward, entire, the small stigma even barely three-lobed; ovules few (4–6) in each cell.

EXPLANATION OF FIGURE 74.

*a*. Flowering plant, just producing offset from the side of the slender stem or scape.
*b*. Lower part of a small plant out of flower, with slender, stolon-like offset enlarging at the apex into a bulb.
*c*. Lower part of a larger plant, with bulb formed without elongation of stalk.

## REVIEWS.

GEOLOGICAL SURVEY OF ILLINOIS.* — This splendid volume is a fit successor to the three preceding, and in every way a credit to the great state that has so liberally provided means for Mr. Worthen to lay the results of his labors, and those of his efficient corps of assistants, before the world.

* Vol. iv. Geology and Palæontology. A. H. Worthen, Director. Imperial 8vo, pp. 508, 31 Plates. By authority of the State of Illinois, 1870.

The geological survey of Illinois was inaugurated by vote of the Legislature in 1851, and was continued for several years without any very important results having been made public. Soon afterwards a strong opposition was made to the survey, but thanks to the stand taken by the Hon. Richard Yates, at the time Governor of the state, a bill discontinuing the survey was vetoed, and in 1858, Mr. Worthen was appointed by Governor Bissell as State Geologist, and from that date the survey has had the continued and liberal support of enlightened legislators, Mr. Worthen being thus enabled to furnish a series of volumes that will rank second only to those of the New York survey, which has been continued for so many years, and has embraced the kindred departments of Zoology and Botany. May we not hope that Illinois will also continue her survey until not only her geology and palæontology are thoroughly reported on, but her Zoology and Botany as well, and a State Museum established that will have within its walls a complete representation of the Natural History of the state. Alas that the building for such a museum was delayed a moment after Mr. Worthen had called attention to its necessity in his first report, for his fears have proved true, and the fine museum of geology and palæontology which had been brought together by the survey has been, since the publication of the last volume, subjected to the fate that sooner or later seems to be the destiny of all museums not placed in fire proof buildings.

The first volume of this survey was published in 1866 and contains a general account of the geology of the state.

The second volume, published in the same year, is devoted to the palæontology, and has fifty plates on which are figured several hundred species of fossils. Especially important is this volume to the student of the fossil fishes and plants of our Coal Measures, in which the strata in Illinois are most remarkably rich.

The third volume of the survey, published in 1868, contains a continuation of the detailed geology of portions of the state, and description of many more fossils, illustrated by twenty plates and many cuts.

The fourth volume, published late in 1870, contains first a continuation of the special geology of thirty-three of the counties in the state, by the Director of the survey and his assistants, Messrs. Bannister, Bradley and Green; and secondly, the continuation of the palæontology of the state, in two sections; first, the fishes by

Prof. J. S. Newberry and Mr. Worthen, second, the plants by Prof. L. Lesquereux.

In the 2d volume of the survey, Messrs. Newberry and Worthen described and figured one hundred and eighteen species of fossil fishes, and in this present volume they add descriptions and figures of thirty-two new species and four new genera, "embracing some of the most remarkable forms yet found in the Carboniferous System" while investigation is being continued on a mass of specimens that will probably "add at least fifty or sixty more species to the list," making a total of over two hundred species of fishes from the Carboniferous System alone, "showing that the western localities of Coal Measures and Lower Carboniferous limestone strata, are far more productive in this interesting group of fossils than any other portion of the earth's surface hitherto explored."

In Prof. Lesquereux's report on the fossil plants, after describing the species that have been discovered since the publication of the second volume of the survey, and giving a systematic table of two hundred and fifty-six species of fossil plants from the Coal Measures of Illinois, he states that the list of species "is more than double that given in the second volume, and that of the recently discovered species, seventy-nine are considered as new, and forty, though known already from Europe, had not been recognized before from our American Coal Measures."

Prof. Lesquereux, in concluding his report on the plants, gives a very interesting account of the "Mode of Preservation of Vegetable Remains in our American Coal Measures" which is of such general interest that we shall reprint it in full in the NATURALIST.

He also devotes a number of pages to "The Flora of the Carboniferous Measures of Illinois, considered in some of its affinities" and to "The Stratigraphical and Geographical Distribution of the Fossil Plants of the Coal Measures."

The thirty-one plates illustrating the palæontological portion of the volume are engraved in a very superior manner by the Western Engraving Company, from drawings made by Prof. Lesquereux, Prof. Newberry and Mr. C. K. Worthen, and the whole execution of the volume is most creditable in all its departments.

From the letter of the Director of the survey, transmitting the manuscript to the Governor for publication, we obtain the gratifying intelligence that the manuscript for the fifth volume is ready for the printer, and the plates for the engraver; and that the

materials for the sixth volume are being prepared for publication as rapidly as possible. These two volumes will include the reports on the remaining counties in the state, and will complete the survey in accordance with the plan hitherto pursued.

New Fossil Crustacea.*—Mr. H. Woodward, who has brought to the notice of naturalists so many crustacea of the older formations especially, describes and figures a new species of Scyllaridia (*S. Bellii*) from the London clay. The genus is allied to the modern Scyllarus, an ally of the Spiny lobster (*Palinurus*). Another interesting form, also figured, is allied to the fish louse, Æga. It is called the *Palæga Carteri*, and is from the Cretaceous formation.

Of the greatest interest, however, are the figures and descriptions of several species of *Cyclus* from the Carboniferous formation of Great Britain. These singular and puzzling forms are round, hemispherical, with the body trilobed, and with well marked segments and deep sutures between them. They are from two to five lines in length. Goldfuss originally figured one species as a trilobite (*Olenus serotinus*), and afterwards Münster referred it to Limulus; while Von Meyer believed it to be neither. Koninck, however, placed it among the aberrant trilobites near Agnostus. In 1868 Woodward said of it, "we must differ from M. de Koninck in referring this form to the Trilobita. If truly an adult, it must be placed near to Apus, with the other shield-bearing Phyllopoda; if a larval form, it may have been the early stage of Prestwichia or some other of the Coal Measures Limulidæ." In the present notice Mr. Woodward reiterates his opinion that "these forms may indeed be the larval stages of Prestwichia, Bellinurus, etc., the antetypes in Carboniferous times of the modern king crab."

In agreeing, so far as we can judge from the figures, with this view, we may say that Limulus sometime before hatching passes through a globular, hemispherical form, with deeply marked sutures, like those observed in several species of Cyclus. Thus the embryonic condition of the modern king crab, was, during the Carboniferous period, probably the mature, or at least larval (not embryonic) condition of the Cyclus. A study of these highly interesting forms will undoubtedly throw light on the affinities of both the king crabs and the trilobites, and indicate that they are

*New British Fossil Crustacea. Extracted from the Geological Magazine, London, 1870. Nos. 11 and 12. With two plates and wood-cuts. pp. 5 and 7.

more nearly related than naturalists have supposed. We trust palæontologists will be on the lookout for these fossils in our Coal Measures.

AGE OF THE MISSISSIPPI DELTA.*—In his "Principles of Geology," Sir Charles Lyell objected to Gen. Humphrey's view in his "Report on the Mississippi River, p. 99," "that this river is flowing through it [the delta region] in a channel belonging to a geological epoch antecedent to the present," stating that the bed of the river might belong to the delta formation. Prof. Hilgard, however, from a reëxamination of the borings made at the artesian well in New Orleans, states that the strata are of marine origin, containing numerous shells of probably quaternary age, so that at that time the mouth of the present river was an estuary. "A river doubtless emptied into the great estuary during the Champlain period of slow depression, but it was not the Mississippi river of to-day, which excavated its bed, partially into these very strata, and acquired its identity during the terrace epoch of elevation." The absence of drift wood, or its debris, "which meets the eye in every microscopic examination of the Mississippi delta deposits," is a "capital objection to the delta-deposit character of these strata."

PEABODY MUSEUM OF AMERICAN ARCHÆOLOGY AND ETHNOLOGY.†—Few people are aware of the value and interest of the collections brought together is this unique museum. Besides the collections already purchased in Europe and previously noticed in this journal, the well known Clement collection of remains from the Swiss Lake dwellings has been lately added.

"It contains, in all, eight hundred and sixty-five specimens. Of these, six hundred and eighty-seven, assigned to the age of stone, are chiefly from localities near Concise and St. Aubin, and were mostly collected by Dr. Clement himself. Of the remains of animals, wild or domesticated, there are those of the ox, hog, sheep, goat, dog, deer, cat, fox, lynx, bear, weasel and squirrel. Among the implements of stone are spear and arrow points, borers, chisels, axes and other kinds of cutting instruments. Many of the stone tools are still retained in their sockets made of the antler of

*Report on the Geological Age of the Mississippi Delta. By Prof. E. W. Hilgard to Gen. A. A. Humphreys. Washington, 1870. 8vo, pp. 16.

†Third Annual Report of the Trustees of the Peabody Museum of American Archæology and Ethnology. Boston, 1870. 8vo, pp. 15.

the deer, and a few of the axes are provided with handles restored after the original patterns, these last having been, in almost every instance, too much decomposed for preservation. There are one hundred and seventy-eight objects belonging to the Age of Bronze, consisting of fragments of pottery, various implements of bronze, such as axes, spear and arrow points, sword blades, fish hooks, pins of various dimensions, pendants and other personal ornaments."

Besides these have been added the collection of the Boston Marine Society, the Thoreau collection, made chiefly about Concord, Mass., a collection of about a hundred objects of stone and pottery from Nicaragua, and a vast collection of Alaskan objects, mostly the work of coast Indians, known as Thlinkets, or more commonly as Kalooshes. "Nearly all the carvings in bone, horn and wood are of the most elaborate and skilfully wrought patterns." These carvings are of unusual interest in connection with the pre-historic carvings by the Reindeer Folk of the caves of France, of which there are specimens in this museum. Indeed, we now have in this country a remarkably full series of the pre-historic remains of Europe, and with the magnificent series of American remains, within the last two or three years placed on exhibition at the Smithsonian Institution, we have nearly as good materials as in Europe for the study of pre-historic man.

Prof. Wyman gives a brief account of his explorations in Florida, especially among the shell heaps. Among the bones, some of the tibiæ "were very much flattened from side to side, as has been observed to be the case with some from other parts of the United States, and in the Old World, from the caves of Dordogne and Gibraltar."

Peabody Academy of Science.*—The second and third annual reports contain an account of the dedication of the Museum in 1869. In an appendix to the reports of the Director, is a note by Mr. Hyatt on a cuttlefish (*Rossia palpebrosa* Owen?) found at Manchester, Mass., where this species has long been used for bait by fishermen. It has not before been met with except in the Arctic regions. The appendix also contains a "Catalogue of Batrachia and Reptilia obtained by J. A. McNiel in Nicaragua," in which Prof. Cope describes as new to science, a lizard, *Tretioscin-*

* Second and Third Annual Reports of the Trustees of the Peabody Academy of Science, for the years 1869 and 1870. Salem, 1871. 8vo, pp. 109.

*cus lævicaudus*, and a new genus and species of snakes, *Enulius murinus*. In the "Catalogue of Reptilia and Batrachia obtained by C. J. Maynard in Florida," Prof. Cope describes a new lizard, *Plistodon onocrepis* Cope, and a new salamander, *Manculus remifer*. Dr. Packard in a "List of Insects collected at Pebas, Equador, and presented by Prof. James Orton" describes as new *Attacus Amazonia*. Mr. Smith in the "List of the Crustacea collected by J. A. McNiel in Central America," describes a number of new crabs: *Leptopodia debilis*, *Ozius integer*, *Arenæus bidens*, *Gebia spinissima*, *Atya rivalis*, *A. tenella*, *Evatya* (n. g.) *crassa*, *Leander gracilis* and *Palæmon tenellus*.

Corals and Polyps of the West Coast of America.*—Of this elaborate work, with its careful and detailed descriptions and most excellent illustrations, we can only give the author's general results, both from want of space, as well as a knowledge of the subject. Two years ago Prof. Verrill called attention to the remarkable contrast between the assemblages of polyps found on the Atlantic and Pacific coasts of Central America, and the bearing of these facts upon the supposed former connection between the two oceans, across the Isthmus of Panama. He is now able to state that "the additional forms now presented make these contrasts still greater and more remarkable, and add greater force to the evidence then brought forward to show that no deep or extensive water connection, sufficient to modify the ocean currents, can have taken place since the existence of the species now living upon each coast."

"The polyps of Panama prove to be remarkably rich in sea fans (Gorgonacea), no less than forty-three species having been already obtained. Of these the genus Muricea appears here to attain to its greatest development, since fifteen species, besides several peculiar varieties, perhaps distinct, are in our collection from Panama Bay, and others from Acapulco and Peru, while from the West Indies there are but four well-ascertained species." "The occurrence of two peculiar, gigantic species of Pavonia, a genus

*Notes on Radiata in the Museum of Yale College. By A. E. Verrill. No. 6.—Review of the Corals and Polyps of the West Coast of America (with 6 plates). No. 7.—Geographical Distribution of the Polyps and Corals of the West Coast of America. No. 8.—Additional Observations on Echinoderms, chiefly from the Pacific Coast of America. No. 9.—The Echinoderm-fauna of the Gulf of California and Cape St. Lucas. (From the Transactions of the Connecticut Academy of Arts and Sciences. Vol. 1.) March 1871. 8vo, pp. 219.

of corals hitherto known only in the Indo-Pacific faunæ, is noteworthy, and also the presence of a peculiar new form of Dendrophyllia."

In the seventh part, on the geographical distribution of the polyps, lists of the species found in the five provinces, between and including the Arctic region and Panama, are given.

Economical Entomology in Canada.*—This subject is wisely taken in hand by the farmers and fruit raisers of Canada and the report on the insects injurious to the apple, grape, and plum, can not but be hailed with joy by those desirous of distinguishing these pests, of knowing their habits, and how to combat them. The information is prepared by those thoroughly acquainted with the subject, and the work is well illustrated, though not so well printed as desirable, a common failing of public documents on this continent. Mr. Saunders' report on the plum weevil, in the same pamphlet, contains an interesting account of the efforts made to capture the plum weevil in large numbers, by the offer of prizes. One person sent in twenty-two hundred and eighty weevils taken by jarring twenty plum trees, ten English cherry and thirty peach trees, between the 24th of May and the 19th of June!

## NATURAL HISTORY MISCELLANY.

### BOTANY.

Darlingtonia Californica.—It is now more than sixteen years since that distinguished botanist, M. Alphonse De Candolle, published in the Bibliothèque de Genève some remarks on the genus Darlingtonia, a translation of which appeared in a horticultural journal of Philadelphia.

M. De Candolle states that the figure of the plant exhibits a character not mentioned by me in the description, and which is very remarkable if it be real; that is, if it be not an error of the

*First Annual Report on the Noxious Insects of the Province of Ontario. Prepared for the Agricultural and Arts and Fruit Growers' Associations of Ontario, on behalf of the Entomological Society of Canada. By Rev. C. J. S. Bethune, William Saunders and E. B. Reed. Toronto, 1871. 8vo, pp. 66.

draughtsman. The five cells of the ovary are represented as *alternate* with the sepals; but in Sarracenia, which he had seen living, the cells of the ovary are opposite the sepals. The artist who executed the drawing is the well known Mr. Isaac Sprague, who made all the illustrations for Dr. Gray's Genera of the Plants of the United States, and in that work the cells of Sarracenia are correctly represented as opposite the sepals. M. De Candolle asks, "Has he committed an error in the plate of the Darlingtonia? Considering his usual accuracy, I doubt it. On the other hand, it is difficult to believe in contrary symmetries in genera so closely allied. I have discovered a similar fact in the family of Campanulaceæ, and it has enabled me to establish several genera, which are, besides, indicated by their external appearance. The thing, then, is not without a parallel, though it is very rare, and should be well examined before being admitted. I would, therefore, point out to American botanists, and particularly to M. Torrey, the great importance of verifying fig. 1 of Sprague's plate."

In making the details of the original drawing, Mr. Sprague had at his disposal only a single flower of a dried specimen, and it was not until recently that I have been able to test, in a satisfactory manner, the accuracy of his analysis. It is known to most of our botanists, that after waiting many years to see the plant in a living state, we have, through the kindness of the brothers Messrs. Henry, who reside near where it grows abundantly in California, and by the liberality and prompt action of Messrs. Wells, Fargo & Co.'s Express, received fresh, living specimens, several of which have flowered. I am now able to state that Mr. Sprague has shown "his usual accuracy" in all the details of his drawing. The cells of the ovary are *alternate* with the sepals. Indeed, I have found scarcely anything to add or alter, now that we have the living plant for comparison.

The theoretical structure of the flower of Darlingtonia, we think, accords with what is actually the case. The stamens are in a single series, and are mostly about fifteen in number. If we assume that they represent only five, each by collateral chorisis increased to three, they will form a verticil alternating with the petals, so that they will necessarily alternate with the carpels also. In Sarracenia the stamens are in a double series, and probably, as in Darlingtonia, multiplied by chorisis; the two verticils alternating

with each other, so that the carpels, in this view, will be opposite the sepals. — J. Torrey, *in Bulletin of the Torrey Botanical Club.*

A Monstrosity in Anemone patens. — While on a recent botanizing tour in the Rocky Mountains, I found a flower of *Anemone patens, var. Nuttalliana*, in which all the numerous pistils are thoroughly transformed into organs resembling petals, so as to give the flower the appearance of being perfectly double.

The five petal-like sepals, and also the stamens, are present in their normal state. The transformed pistils are somewhat longer than the sepals, but of the same pale purple color. The outermost, or those next the stamens, are three parted, as if to represent the leaves of the plant, while the central ones are entire, like the sepals. The root which produced this beautiful anomaly, bore three other scapes, each with a flower perfectly normal.

The specimen I have carefully preserved, as a most interesting instance of a wild flower becoming double without the aid of cultivation. But why were not the other flowers which grew from the same root also double? — Edward L. Greene, *Golden City, Colorado.*

[Why not? *Quien sabe?* By the way, full double *Thalictrum anemonoides* is found now and then in perfectly wild plants, and sometimes in *Anemone nemorosa.* — Eds.]

Ajuga reptans L. — I have detected this plant growing abundantly in a field in Saco, Maine, where it appears to be well established. It resembles *Brunella vulgaris* so closely in its habit, that I think it may have been overlooked elsewhere. It has been before (1851) found near Montreal, but not, so far as I can learn, in the United States. — G. L. Goodale.

## ZOOLOGY.

The Humming Bird. — In the month of June, 1870, we discovered a Ruby-throated humming bird building its nest near and a few feet below our chamber window. We observed carefully the building of the nest, the period of incubation and the time that the young left the nest. On the 14th of June we first saw the bird building the nest on top of a horizontal branch of a pear tree; the branch was about three-quarters of an inch in diameter under the nest. The bird built up the side farthest from the house first,

and built one-half of the circle its full height; the last half of the nest she built in one day with the exception of finishing the outside with lichens. June 16th she laid the first egg and was busy at work all day covering the outside of the nest with lichens, and was one week longer finishing the outside of the nest. June 17th she sat on the nest all day; on the 18th the second egg was laid and was larger than the first egg. On the morning of the 3d of July both of the eggs were in the nest and at noon there were two young birds; this makes the period of incubation fifteen days from the time the last egg was laid. July 10th, we examined the nest, and found but one young bird; it had a little down on it, but no feathers. July 13th, I examined the young bird and found it covered with pin feathers. On the 15th it picked its feathers and had quite a long bill. The 19th, after being fed it stood up in the nest and made its wings move rapidly, as though it was trying to fly. On the 23d of July the bird left the nest, which made twenty days that it remained in the nest. We did not see a male humming bird near the nest at any time, but a neighbor's cat caught and killed two or three male birds, and it may be that it caught the mate to our bird. The old and young birds remained in the garden until late in the autumn and were quite tame; the young bird would allow me to walk within four feet of it and examine it. You will see by this that both the period of incubation and the time that the young bird remained in the nest are longer than given by Audubon and Samuels. — LABURTON JOHNSON, *Bradford, Mass.*

POSITION OF THE BRACHIOPODS. — At the meeting of the Boston Society of Natural History held March 15, Prof. Edward S. Morse referred to the communication of Mr. Wm. H. Dall, "On the Relations of the Brachiopoda" read at the preceding meeting.

Prof. Hyatt said his objections to Prof. Morse's classification of the Brachiopoda had heretofore rested wholly upon the presumed affinities of the Polyzoa and Ascidia. He had been led by the similarities of the adult animals of the two groups to partially follow Prof. Allman in his opinion that these two groups were closely related. In a paper on the Fresh Water Polyzoa (Proceedings Essex Institute, vol. iv.) he had compared them, but had at the same time shown that the differences were much greater between the Polyzoa and Ascidia than between the former and the Brachiopods. Thus, there is no muscular system in the Ascidia which

can compare in any sense with that of the Polyzoa; and in transforming the Polyzoon into an Ascidian, Prof. Allman is obliged to violate this obvious difference, as well as to effect many changes which are not consistent with their organization. The nearer affinity of the Polyzoa and Brachiopoda is hardly questionable since the investigations of Koraleusky, who has shown us that the young Ascidians are apparently more like young vertebrata than they are like the young of the Polyzoa. The importance and value of the resemblances existing between the adult Polyzoon and the adult Ascidian, so far as they may be supposed to indicate any close affinity or community of origin are thus doubly denied by the differences of form and structure, both in the adults and in the larvæ.

The Ascidians are also likely to be removed by these new discoveries, not only entirely away from the Polyzoa, but to an equal or greater distance from all the rest of the Mollusca; and even if we could in the face of embryology still maintain our comparison between the two structures, we should be contrasting the Polyzoa, not with a typical Mollusk but with an animal whose own position is very uncertain. I can think of no fundamental molluscan characteristics, either in the Brachiopods or Polyzoa, which ally them with the Lamellibranchs (clams), except those which join them still more closely to the Ascidians. Therefore it seems clear, that if we separate the Ascidians from the Lamellibranchs, which they so closely resemble in their general adult characteristics, on account of their different developments, we must also, in turn, remove the Polyzoa from the Ascidians, and should logically regard the similarities of the two as analogies arising in different structures, and not as affinities derived from some common ancestor. Thus cut off from its quondam molluscan allies our Polyzoon has but one refuge; its development points concisely to a vermian ancestor, and to this source we must relegate both it and its nearest ally, the Brachiopod.

Prof. Morse called attention to the fact that Kowalewsky, Hæckel, Darwin and others had pointed out the relationship apparently seen in the embryo of certain Tunicates, and the typical idea of the vertebrate embryo. Without expressing an opinion for or against this view, it was interesting to remark that many eminent naturalists had seen reason to include the Tunicates with the Vermes; and in the supposed relation, on the other hand, of the Tu-

nicates with the Vertebrates, it was interesting to recall two prominent features of the Vermes that are likewise prominent characters of the Vertebrates, namely: hairs or setæ secreted by follicles, and genitals in pairs, with infundibuliform orifices, suspended freely in the perivisceral cavity.

A Zoologist on the Pacific Coast.—Dr. S. Kneeland gave an account at the same meeting of a trip which he made in 1870, by sea, from San Francisco to Panama, and presented a few specimens which he had collected. He described the climate, the general appearance of the coast, and incidents of the voyage, and referred to the habits of some of the sea birds and of the flying-fish. Large petrels (*Puffinus cinereus*) he said, began to appear and followed us on the second day out. On alighting in the water, which they often do, they put forward their webbed feet, checking their headway in this manner, backing water as it were with the wings spread, before settling on the surface. They came round and near the steamer in considerable numbers, but never alighted on it as the booby of the Atlantic does. On account of the great length of their wings and the shortness of their legs, they cannot rise, like the gulls, directly from the water, but are obliged to run along the surface like the smaller petrels, beating the water with their feet until sufficiently elevated to use their wings.

Flying-fish also began to appear, but neither so numerous nor so large as in the Southern Atlantic. The ventrals were expanded just like the pectorals in the act of flight, the former being much the smaller. They rose out of a perfectly smooth sea, showing that they are not mere skippers from the top of one wave to another; they could be seen to change their course, as well as to rise and fall, not unfrequently touching the longer, lower lobe of the tail to the surface, and again rising, as if they used the tail as a powerful spring. While the ventrals may act chiefly as a parachute, it seems as if the pectorals performed, by their almost imperceptible but rapid vibrations, the function of true flight. Another reason which led him to think they perform a true flight is the way in which they reënter the water. After reaching the end of their aërial course, they drop into the water with a splash instead of making a gradual and gentle descent, like the flying-squirrel, flying-dragon, and other vertebrates with mem-

branes acting as parachutes. The drying of the flying membrane in the air would prevent the small but numerous motions necessary for true flight, and the animal, therefore, suddenly drops when the membrane becomes stiff. He could not see how the drying of the pectorals would effect their action as parachutes.

At the same time there were seen small Portuguese men-of-war (*Physalia*) no larger than an olive, and without the purple reflections of the larger ones so often met in the Atlantic. Whether these were the young, or full-grown individuals, he did not know. He saw none larger than these, and they were not numerous.

As he approached the coast off the Gulf of California the petrels disappeared and were replaced in an hour or two by white gulls, about the size of Bonaparte's gull, but either entirely white or with a very slight lavender-blue tinge on the back and wings. These had an entirely different way of alighting and rising from the water; they did not push forward their feet to arrest their course, but circled round like pigeons until their headway was stopped, then quietly settled upon the water immediately folding their wings. They also rose directly from the surface without running along as the larger winged petrels did.

Migrations of Moths.—Our readers are familiar with migrations of butterflies, and now we see noticed in "Nature" the migration in "amazing numbers" of *Urania Leilus*, which mimic butterflies not only in their size, and disposition and colors of their scales, but also in this habit of swarming, which we do not remember to have seen noticed in other moths. This Urania was seen flying in swarms across the Isthmus of Panama, and also by another person near Para, Pernambuco, and Rio Janeiro. "From an early hour in the morning until nearly dark these insects passed along the shore in amazing numbers, but most numerously in the evening. It was very seldom that one was seen in the opposite direction."

The Urania is scarcely, as "Nature" suggests, "something between a skipper [Hesperia] and a hawk moth," but a true Geometer. A careful examination of the structure of the moth shows us that it is nearly allied to Chœrodes and Urapteryx. To this position Guenèe has also assigned it.

Rapid Growth of the Pickerel (*Esox reticulatus*).—This fish, like all bad characters, makes a worse show the more he is studied. Dr. E. L. Sturtevant investigated their powers of eating, in the

following manner. He put two young pickerel, about five inches long, in a trough with a great quantity of little minnows of about one inch in length; and these two pickerel ate one hundred and twenty-eight minnows the first day; one hundred and thirty-two the second; and one hundred and fifty the third! and *they increased one inch in length in forty-eight hours!* They were mere machines for the assimilation of other organisms!—*Fifth Report of Mass. Commissioners of Inland Fisheries*, 1871.

Ticks in the Ear.—I can tell a tale about a tick in *my* ear (see Naturalist, May, p. 176). In Cuba I was lost in the woods. I slept one night on the ground. A day or two thereafter feeling a curious buzzing in my ear I lay down on the opposite side and filled the ear with water. It was not very long before the tick loosened its hold and was taken out. I know nothing of the species but suppose it was the common horse or cattle tick of that island.—C. Wright.

The Star-nosed Mole.—In January, 1869, I noticed mole tracks and burrows in the snow in Niles, Michigan, and soon saw the star-nosed mole making similar tracks and burrows. He was apparently as lively as if it had been summer. Is it common for this animal to be abroad thus in the winter?—Sanborn Tenney.

White Spotted Muskrat.—I have a muskrat skin that has a narrow white spot upon the back, between two and three inches long; also two patches of white upon the head. There was also white about the mouth.—W. C. Fish.

## GEOLOGY.

Discovery of Mastodon Remains at Mott's Corners near Ithaca, N. Y.—A few days ago a son of Mr. J. P. Allen, of Mott's Corners, in digging a ditch to drain a small peat bog, discovered two teeth of Mastodon. With more than ordinary good sense, he immediately stopped digging and the specimens were carried to Cornell University. A party consisting of Mr. Cornell, Pres. White, Dr. Wilder, Prof. Brown, a student and myself visited the spot and made further excavations which furnished only fragments of bones. Since then other parties have secured three more teeth and a considerable quantity of broken bones.

The locality is situated in the deep valley of Six Mile Creek, excavated in Chemung rocks. The bottom of this valley has been

filled up with a great thickness of drift, through which the creek has cut here and there down to or into the solid rock. At the mastodon locality the stream met with a little knob of Chemung rocks which appears to have formed at one time an island, but the creek afterward cut its way through the rock to a lower level on the left side and the channel on the opposite side was deserted. Springs, one of which is said to be salt, have kept this deserted channel wet and a bed of peat has formed which once supported some large trees. The layer of peat varies from a few inches to two feet or more and is full of sticks, pine knots, bark, etc., more or less decayed. Beneath this is a layer of variable thickness, rarely more than a few inches, composed of clay mixed with pebbles and pieces of shale. In this were found small fragments of bones and teeth, the former in a very decayed condition showing that the skeleton had been completely broken up and scattered. The whole rests on a bed of blue arenaceous clay with large pebbles and fragments of rock of all kinds, in fact, a modified drift. In most cases the bones were merely scattered over the surface of this bed between it and the peat. The teeth are in very good condition and not at all waterworn. The animal probably became mired near the spot. The skeleton, exposed to the action of the elements, went to pieces, and the fragments were scattered, partly by water action and partly through the agency of wild animals.— Ch. Fred. Hartt, *Cornell University*, *May 25th*, 1871.

The Discovery of a Skull of a Musk-ox in Utah.—The skull referred to in the "Salt Lake Tribune" this morning, is quite different from the skull of a buffalo. The long, heavy, drooping horns mark it as the skull of a musk-ox—an animal now found only within, or near, the arctic regions. It is an exceedingly interesting relic to the geologist as an aid in reading the ancient history of this valley. The skull, which is in a good state of preservation, was imbedded about eight feet below the surface in a layer of coarse, stratified gravel, with layers of sand and finer gravel above and below it.

Much of the work of filling the valley had been accomplished before this relic was deposited, but it found its resting place long before the work was completed, and long before Salt Lake wore water lines in the mountains above the "benches." Musk-oxen and the foot-prints of glaciers left on the quartz rocks of some of these canyons, suggest a former climate quite unlike that which

now makes the valley such a fruitful garden.—P. A. Chadbourne, May 16, 1871. *From the Salt Lake Tribune.*

Fossil Walrus.— At a meeting of the New York Lyceum of Natural History, held during last autumn, Prof. Newberry, the President, exhibited the anterior portion of the cranium of a walrus which had been found during the summer at Long Branch by a gentleman whose foot struck against it while bathing. It was strongly silicified, but exhibited no appreciable difference from modern specimens. The precise age of this fossil could not, of course, be ascertained, although it is well known that its range was formerly much south of its present habitat. It is not unfrequently brought down on floating ice off the coast of Newfoundland; and although Labrador is at present the southern limit of its residence, it was once very abundant in the Gulf of St. Lawrence, and its remains have been found in the shell-heaps of the Bay of Fundy. It is probable that the specimen exhibited by Prof. Newberry is a relic of the glacial period, although it was suggested that it might have been of the tertiary age, which probably cannot be verified. Other specimens of similar character are recorded as having been found on Martha's Vineyard; in Monmouth Co., New Jersey; and in Accomac Co., Virginia.

The Pterodactyl in America.—Prof. Marsh states in the American Journal of Science and Arts, that the Yale College party obtained in addition to the cretaceous fossils already spoken of, several specimens which indicate a huge flying reptile, which he names *Pterodactylus Owenii*. The bones discovered "indicate an expanse of wings not less than twenty feet." The remains were found by Prof. Marsh in the upper cretaceous formation of Western Kansas. This is the first occurrence of the Pterodactyl in America.

## MICROSCOPY.

Monochromatic Illumination.—Whenever I want to make out some of the minutest details of any organism, or to get over any difficult test, and I see that my microscope, after all due preparation, and with the best prospect of light, fails to answer my expectation, I refer, as a last resource, to my prism, and get from it a colored sunbeam. Blue or green are the colors which I prefer; they are the most suitable for the purpose.

The elimination of every, even the slightest, chromatic aberration obtained by this means increases, in my opinion, the defining and penetrating power of the microscope, and enlarges its dominion on the field of observation. Different other means have been now and then suggested, such as an alcohol light saturated with chlorine of iodine, or a light passed through a stratum of cupreo-ammoniacal solution, or even through a glass of cobalt; all these lights may be very useful and for some special purpose even preferable to any other, as Dr. Woodward observed, speaking of photography; but for direct observations with the microscope, the effects obtained by them are by no means to be compared with the marvellous results of a mono-chromatic illumination. And I do not think it absolutely necessary for this purpose to have recourse to a beam of the *sun*, which in many countries less favored than Italy is not rarely a mere desideratum, and very often a dim, cloudy thing. A brilliant luminous point of electric light — a light obtained from oxhydrogenic flame — acting upon lime, magnesium, or zirconium, perhaps also the magnesium-wire lamp, may supply the deficiency of the sunbeam. Each of these simply white lights decomposed through a prism, will give a mono-chromatic illumination sufficient to reveal the best structural details, which up to this day have baffled the keenest researches of the student.— Count Castracane, *Monthly Microscopical Journal.*

## ANTHROPOLOGY.

Supposed Indian Corn Huskers. — In the museum of the Smithsonian Institution are several Indian stone implements like that noticed on p. 16 of the present volume of this journal, which are said to bear a striking resemblance to iron corn huskers now in use in the West. —Eds.

# NOTES.

At the Manchester Literary and Philosophical Society, Mr. Boyd Dawkins exhibited a number of casts in plaster of Paris of various objects of natural history, and explained the process by which any one can make them for himself. The material of the

mould is artists' modeling-wax, which is a composition akin to that used by dentists; and, as it becomes soft and plastic by the application of heat, though in a cold state it is perfectly rigid, it may be applied to the most delicate object without injury. As it takes the most minute markings and striations of the original to which it is applied, the microscopic structure of the surface of the original is faithfully reproduced in the cast. This method is briefly this: 1. Cover the object to be cast with a thin powder of steatite or French chalk, which prevents the adhesion of the wax. 2. After the wax has become soft, either from immersion in warm water, or from exposure to the direct heat of the fire, apply it to the original, being careful to press it into the little cavities. Then carefully cut off the edges of the wax all round, if the undercutting of the object necessitates the mould being in two or more pieces, and let the wax cool with the object in it, until it is sufficiently hard to bear the repetition of the operation on the uncovered portion of the object. The steatite prevents the one piece of the mould sticking to the other. The original ought to be taken out of the mould before the latter becomes perfectly cold and rigid, as in that case it is very difficult to extract. 3. Then pour in plaster of Paris, after having wetted the moulds to prevent bubbles of air lurking in the small interstices; and, if the mould be in two pieces, it is generally convenient to fill them with plaster separately before putting them together. 4. Then dry the plaster casts either wholly or partially. 5. Paint the casts in water-colors, which must be fainter than those of the original, because the next process adds to their intensity. The delicate shades of color in the original will be marked in the cast by the different quantity of the same color, which is taken up by the different textures of the cast. 6. After drying the cast, steep it in hard paraffine. The ordinary paraffine candles, which can be obtained from any grocer, will serve the purpose. 7. Cool, and polish the cast by hand with steatite. The result of this process is said to be far better than that obtained by any other.— *The Manufacturer and Builder.*

The American Museum of Natural History held an exhibition of its collections in the Arsenal building, in the Central Park, to invited guests, April 27th. This Association was incorporated some two years since, and has made excellent progress in establishing a museum. The cases are said to contain nearly one thou-

sand mammals, ten thousand birds, and two thousand fishes and reptiles. There are also nearly four hundred mounted skeletons of the various orders. The insects number more than ten thousand, and shells about that number. Also a few geological specimens of no great value. There are no mineral collections as yet. The insects were presented by Baron Osten Sacken, R. A. Witthaus, and Coleman T. Robinson. The shells are the gift of Albert S. Bickmore and William A. Haines. The remainder of the collections was obtained by purchase in this country and Europe. The Department of Public Parks, under the authority granted by the last Legislature, will commence in the autumn the erection of a permanent building in Manhattan Square, for this collection. The cost of the new building will not exceed five hundred thousand dollars.—*American Chemist.*

Prof. Baird, of the Smithsonian Institution, who was last spring appointed by the President and confirmed by the Senate as United States Commissioner of Fish and Fisheries, will visit the coast of New England during the coming summer, making his head quarters at Wood's Hole. The act of Congress under which the Commissioner is appointed makes it his duty to prosecute investigations with a view of ascertaining whether any and what diminution in the number of valuable fishes has taken place, and if so, to what causes the same is due. He is also to report to Congress whether any and what protective prohibitory or precautionary measures should be adopted in the premises.

We understand that Prof. Baird will dredge extensively both at the surface and at the bottom, and the investigations will be of great interest to naturalists, several of whom will join him in his explorations.

The Providence Franklin Society celebrated its semi-centennial anniversary on May 9th. This society has been more active in the past than of late years, but seems now to show unusual activity. Several scientists of eminence have been active members, and we trust a new life and energy will be infused into its present working staff.

Silk worm eggs from Japan, to the amount of one hundred and thirty-five thousand cards, costing in that country six hundred and seventy-five thousand dollars, lately arrived in San Francisco. —*American Chemist.*

We are sorry to learn that the Government of Nova Scotia, in resorting to the retrenchment system, has withdrawn the small, annual grant heretofore made to the Institute of Natural Science, the only scientific society that colony possesses; and, moreover, one which for the past eight years has struggled to maintain a position creditable to itself and the country in which it is established. Surely the trouble and expense of publishing, setting aside the gratuitous mental labor of those members who have furnished the interesting papers which together form the eight annual parts, comprising two volumes of over one thousand pages, should have been considered by the authorities of the colony before they acted in such an illiberal spirit. We trust, nevertheless, to see the Institute still progress in its career of usefulness. — *Nature.*

Prof. Agassiz has accepted an invitation extended to him by the Coast Survey Bureau to take passage on the iron coast survey steamer, which has just been built near Wilmington, Del., and which sails for the Pacific coast in September next. The expedition will take deep sea soundings all the way, and extensive collections of specimens will be made for the Museum of Comparative Zoology at Cambridge.

Secretary Boutwell has written to the Secretaries of State and Navy asking that naval and other officers may be instructed to afford such courtesy and assistance to the exploring party as may be desirable.

We learn that Count Pourtales of the Coast Survey and Rev. Dr. Hill will accompany the expedition.

The Legislature of Arkansas has passed a bill providing for a geological survey, and making an appropriation of fifteen thousand dollars for beginning the work. The position of chief geologist, salary two thousand eight hundred dollars per annum, was tendered to Prof. Edward Orton, of Antioch College, one of the assistant geologists on the Ohio survey, but has been declined by him.— *American Chemist.*

The President of the Geological Society of Glasgow thinks the phosphate deposits of South Carolina are of Eocene Tertiary age. This is quite a mistake, as they are of Quaternary age. The bones he refers to were washed out of Eocene strata, but they are

associated with Quaternary mammals such as the tapir, horse, mastodon, mammoth, megatherium, dinotherium, etc.

The Maryland Academy of Sciences held its annual meeting in May, electing Rev. Dr. J. G. Morris, President, and Rev. E. A. Dalrymple, Corresponding Secretary, with the usual officers. This society holds field meetings, and otherwise shows considerable activity.

The State Geological Rooms at Springfield, Illinois, were burned on the twenty-second of February, and the state collections were greatly damaged by water and hasty removal.

The Record of Entomology for the year 1870 is now published. The design of this useful annual is to collect from various periodicals and transactions of societies, the titles of articles and notices of new discoveries in entomology, thus giving a record of the progress of American entomology each year. In this way the isolated descriptions of new species, and notes about the habits of insects are indicated so that the working entomologist is greatly aided in collecting the materials for study. It also gives foreign entomologists a summary of what has been done in this country, and thus brings the working entomologists of both hemispheres into closer relations. The work is advertised in the present number.

## ANSWERS TO CORRESPONDENTS.

S. J., Hudson, Mass. — The plant you send is the *Habenaria virescens*. It belongs to the Orchis family and is not uncommon in wet places where the skunk cabbage grows. — J. L. R.

C. G. A., Augusta, Me. — The specimens you send from the pine tree of about sixty feet in height are pronounced by Prof. Gray to be unquestionably from the *Pinus Banksiana* as you supposed. Your Orland tree is remarkable for its height.

S. S. C., — Speaking of the enemies of the oyster a correspondent writes: — "Along the tidal rivers and sounds of East Florida are vast beds of oysters, many of which are seen when the tide falls to have been opened and the animal removed. It was difficult to understand by what agency this was done. Inquiring of an intelligent native pilot and fisherman, I was told that the Sheepshead and Drum, fishes whose principal food consists of crustacea and mollusks, are able with their strong jaws and pavement-like teeth to crush the shells of the oyster sufficiently to extract the animal. Moreover, the Conch (Turbo), [Does not our correspondent mean the Strombus?] which shell-fish is very common on these coasts, inserts its hard and horny operculum (which well represents an oyster knife), between the shells, pries them open, and sucks out the oyster with a fleshy tube, or proboscis. This Conch, which is from six to ten inches long, puts out a foot, upon which it can travel along the bottom. It walks to the oyster bed, deliberately pries open the oyster, and takes him raw on the half shell; a remarkable performance indeed, for a Gasteropod." We submitted this communication to an eminent naturalist, who has spent much time exploring in Florida, who replies as follows: — "Gasteropods do not open oysters with their opercula. The Turbo in fact is a vegetable feeder. The oysters are killed by frost in severe 'northers,' and when the animal decomposes, the shells, of course, open by the elasticity of the cartilage. No fish has teeth strong enough to crush oyster shells; they frequent the beds for the smaller shells and crustacea which harbor there."

## BOOKS RECEIVED.

*First Annual Report on the Injurious and Beneficial Insects of Massachusetts.* By A. S. Packard, jr., Entomologist to the State Board of Agriculture. Boston, 1871. 8vo, pp. 31. 24 figures.

*Canadian Naturalist and Quarterly Journal of Science.* Vol. 5, No. 3. Sept., 1870. (April, 1871.) Montreal.

*Proceedings and Communications of the Essex Institute.* Vol. 6. Part 2. 1868-71 (March, 1871). [Concluding the work.] Salem.

*Annual Report of the Board of Supervisors of the Louisiana State University for* 1870. New Orleans, 1871. 8vo, pp. 271. [Contains 2d Annual Report of the Topographical Survey of La., by Col. S. H. Lockett, pp. 55; 2d Annual Report of the Geological Survey of La., by F. V. Hopkins, M. D., pp. 35 and map; Report of Botanical Survey of Southern and Central La., by Prof. A. Featherman, pp. 131; and a list of the shells.]

*Museum Godeffroy. Catalogue IV.* Hamburg, 1869. pp. 139.

*On the Physics of Arctic Ice, as Explanatory of the Glacial Remains in Scotland.* By Robert Brown. 8vo, pp. 31. London, 1871.

*Descriptions of some new or little-known species of Oaks from North-west America.* By Robert Brown. 8vo, pp. 8. London, 1871.

*Bulletin of Museum of Comparative Zoology. Vol. 2, No. 5. Appendix to the Preliminary Report (Bulletin. No. 9, Vol. I.) on the Echini collected by L. F. de Pourtales.* By Alexander Agassiz. pp. 3. April, 1871. Cambridge.

*Memoirs Boston Society of Natural History.* Vol. 2, No. 1. January [May], 1871. Contains Historical Notes on the Earthquakes of New England, 1638-1869, by Wm. T. Brigham.

*The Discovery of the Force which in the beginning put all the Heavens and the Earth in Motion.* By Jacob Ennis. 8vo, pp. 23. Cambridge, 1871.

*Annales Academici.* 1865, 1866. 4to. Lugduni-Batavorum, 1870.

*Denkschrift auf C. E. Hermann von Meyer,* von C. A. Zittel. 4to, pp. 50. Munchen, 1870.

*Memoirs de la Societe de Physique et d'Histoire Naturelle de Geneve.* Tome xix, 1st part, 1867. Tome xx, 2d part, 1870. 4to. Geneve.

*Sitzungsberichte der k. k. Akademie der Wissenschaften zu Munchen.* Jahrgang, 1870. Band II. 8vo. Munchen, 1870.

*Journal of the American Geographical and Statistical Society.* Vol. 2, Nos. 1, 2; 1869 and 1870. 8vo. New York.

*Journal of the Queckett Microscopical Club.* April. London.

*The Profession of the Mechanical or Dynamical Engineer.* An Inaugural Address by W. P. Trowbridge. 8vo pamph. Philadelphia, 1871.

*Anæsthetics.* By E. R. Squibb, M. D. pamph. 8vo. New York, 1871.

*Notes on Radiata in the Museum of Yale College.* No. 6.—Review of the Corals and Polyps of the West Coast of America (with 6 plates). No. 7.—Geographical Distribution of the Polyps and Corals of the West Coast of America. No. 8.—Additional Observations on Echinoderms, chiefly from the Pacific Coast of America. No. 9.—The Echinoderm-fauna of the Gulf of California and Cape St. Lucas. By Prof. A. E. Verrill. 2 pamphs. 8vo. [From the Trans. Conn. Acad. Arts and Sci. Vol. 1, 1868-71.]

*On the Geology of the Eastern Uintah Mountains.* By Prof. O. C. Marsh. 8vo, pp. 8. Mch., 1871.

*Notice of a Fossil Forest in the Tertiary of California.* By Prof. O. C. Marsh. 8vo, pp. 4. Apr., 1871.

*Description of Some New Fossil Serpents from the Tertiary of Wyoming.* By Prof. O. C. Marsh. 8vo, pp. 7. May, 1871.

*Æsthetic Culture in the Troy Female Seminary.* By Mrs. John H. Willard, and *Plan for Improving Female Education.* By Mrs. Emma Willard. 8vo, pp. 32. Troy.

*Amazonian Drift.* By Prof. C. F. Hartt. 8vo, pp. 3. April, 1871.

*Report on the Action of Cochituate Water upon Lead Pipes.* By W. R. Nichols. 8vo, pp. 27. Boston, 1871.

*Notes relating to the Physical Geography and Geology of, and the distribution of Terrestrial Mollusca in, certain of the West India Islands.* By Thomas Bland. 8vo, pp. 8. March, 1871.

*Notes on Chalcidiæ. Part I.—Eurytomidæ.* By Francis Walker. 8vo, pp. 17. London, 1871.

*A New Genus and Species of Chalcidites.* By F. Walker. 8vo, pp. 2. London, 1865.

*Notes on Chalcididæ and Description of a new species of Megastigmus.* By F. Walker. 1869.

*Genres des Poissons de la faune de Cuba appartenant a la famille Percidæ.* Par Felipe Poey. 8vo, pp. 79 and plate. New York. [From Ann. Lyc. Nat. His. Vol. x.] 1871.

*Arrangement of the Families of Mollusks prepared for the Smithsonian Institution.* By Theo. Gill. 8vo, [S. I. Miscel. Coll.] pp. 49. 1871.

*Annals of the Lyceum of Natural History of New York.* Vol. x. Nos. 1-3. Feb.-March, 1871.

*On the Aymara Indians of Bolivia and Peru.* By David Forbes. 8vo pamph., pp. 113. 7 Plates. London, 1870. (Communicated to the Ethnological Society of London, 1870. Contains also a discussion of the subject by Mr. Squier and others.)

*Geological Survey of Canada.* Report of Progress from 1866 to 1869, accompanied by Geological and Topographical Maps. Alfred R. C. Selwyn, Director. 8vo, pp. 475. Montreal. 1870.

*Conchological Memoranda, No. VI. Preliminary Descriptions of New Species from the West Coast of America.* By R. E. C. Stearns. May 18, 1871. 1 p. 8vo.

*Notes on the Chalcidiæ. Part I.—Eurytomidæ.* By Francis Walker. 8vo pamph., pp. 17. Cuts. London, 1871.

*Third Annual Report on the Noxious, Beneficial, and other Insects of the State of Missouri.* By Charles V. Riley, State Entomologist. 8vo pamph., pp. 175, 273 cuts. State Document, 1871.

*On the Influence of the Blue Color of the Sky in Developing Animal and Vegetable Life, as illustrated in the Experiments of* Gen. A. J. Pleasonton. Philadelphia, 1871. 8vo pamph., pp. 24.

*American Journal of Conchology.* Vol. 6, Part 4. (June.)

*Archiv fur Anthropologie.* Vierter Band, 1870. 4to. Braunschweig, 1871.

*Feuille des Jeunes Naturalistes.* No. 7. May 1, 1871. Dornach.

*Catalogue, etc. Columbia College.* 1871.

*American Bee Journal.* May, June.

*Bowdoin Scientific Review.* Nos. for May.

*Bulletin of the Torrey Botanical Club.* April, May.

*American Journal of Microscopy.* Vol. 1, No. 1.

*Journal of the Franklin Institute.* May, June.

*Le Naturaliste Canadien.* April, May.

*American Journal of Science and Arts.* June.

*Nature.* Nos. for May and June.

*Land and Water.* Nos. for May.

*The Field.* Nos. for June.

*The Academy.* Nos. for May and June.

*Science Gossip.* June.